UNDERSTANDING THE SKILL OF

FUNCTIONAL TASK ANALYSIS

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SUMMARY

Functional task analyses are methods used to discover and represent a task in terms of goals and subgoals. Although widely used, little is known about the nature of expertise they involve. The few existing training studies indicated that learning task analysis is not trivial (e.g., Patrick, Gregov, & Halliday, 2000; Stanton & Young, 1999). To contrast the "task analysis is an art" explanation, this dissertation approached task analysis as a skill acquisition problem that can be understood through scientific inquiry.

Two studies were designed to capture and characterize experienced and novice performance and to identify skill components of functional task analysis. Professional (Study 1) and novice (Study 2) task analysts analyzed six tasks, four familiar and two unfamiliar ones from two different domains: *making peanut butter jelly sandwich, making breakfast, and making Vetkoek* (domain of cooking)*, and making phone call, arranging a meeting, and sharing pictures using Adgers* (domain of communication). Master task analyses for each task served as a basis for comparison.

Study 1 involved eight professional task analysts (at least two years experience, at least one task analysis conducted in the past year). Participants analyzed tasks while thinking aloud, completed questionnaires, and partook in a semi-structured interview. Professionals' task analysis products were characterized in terms of hierarchical breadth and depth, versatility, and task boundaries. Analyzing the process of task analysis focused on professionals' general approach (breadth-first or depth-first) and the kinds of questions and assumptions participants expressed.

Study 2 focused on novices with the goal to characterize their untrained and trained performance on a number of tasks. Did participants generate the required

procedural knowledge after a brief period of declarative, whole-task training, and did performance differ depending on instructional material? Thirty six participants analyzed one task before and five after receiving instructions. A recall test asked participants to list five main features of HTA. Novices improved on some features of HTA (e.g., hierarchy depth, stating main goal), but performance was significantly below 100% on other features. Instructional material did not matter in this short period of training.

Task analyses of both participant groups showed similar dimensions of the hierarchy (breadth and depth of the analysis). Novices' initial task analyses were flat but significantly deeper after training, comparable to a level of professionals' task analyses. However, both groups produced task analyses of just one level. The majority of both groups' task analyses fell within prescribed boundaries of three to eight subgoals wide, but also included too broad and narrow ones. Overall, half of professionals' task analyses were approached breadth-first. Future studies could follow up on the association between the breadth-first and depth-first approach and the subsequent breadth and depth dimensions.

Novices identified a larger number of subgoals (verb-noun pairs) after training, but kept their focus on lower level subgoals, a pattern also found for professionals' task analyses. Both groups included learning-related activities for unfamiliar tasks; although one professional explicitly excluded it from the task analysis. Experienced task analysts tended to separate verb-noun pairs from each other whereas novices tended to chunk verb-noun pairs together (e.g., paragraph style). Future directions could follow up on these differences in the "unit of analysis" (delineating subgoals from each other). A potential strategy of professionals' for identifying subgoals may be that of symmetry (what needs to be open also needs to be closed). Further research could determine if and how professionals' task analysis changes with revisions to this 15-minute draft.

Half of both participant groups' task analyses were specific, and professionals' think-aloud data indicated possible reasons: purposely constraining the task analysis, modeling an existing technology, or the purpose of the analysis. Professionals used questions and assumptions to guide their process and constrain their task, understand the task space and its objects, and search the task space. The most frequently asked questions in this phase were "what", followed by "how".

Contributions to Theory

Skill components of functional task analyses were derived from the findings in both studies. Data and literature indicate that task analysts' domain of expertise involves extracting, creating, and applying task structures as a procedural skill component, but with different emphasis. The associated, accumulated declarative knowledge may be characterized by the type of task routinely encountered (e.g., monitoring task) which provides the basis for pattern-based retrieval.

Practical Implications

The results of this dissertation can inform training of HTA (and functional task analysis in general). Novices expanded their task representation space but did not spontaneously generate the procedural knowledge required. Instructions thus should focus on identifying and delineating subgoals and define the terms "goal" and "purpose" as they relate to the task and the task analysis. The questions and master task analyses could be used a training tool.

CHAPTER 1: INTRODUCTION

This chapter introduces an applied problem, the training of task analysis. After showing why training of task analysis requires investigation, the challenges involved in task analysis are discussed along with the benefits and goals of a skill acquisition approach.

What Is Task Analysis and Why Do We Need It?

Task analysis is a commonly used approach to extract detailed information about a task. Many definitions of task and task analysis exist, depending on how broadly one defines a ”task” and in which stage of the design process task analysis is used. In general, a *task* can be defined as a piece of work to be done. Depending on the level of analysis, a task may be defined on a system level, such as “operating a chemical plant” or on a lower level such as “making a photocopy”. *Task analysis* can then be described as a collection of methods used to collect, analyze, and organize information about a task with the goal to understand a person’s work (Kirwan & Ainsworth, 1992, and see Redish & Wixon, 2003, for a review and analysis of various definitions).

Performing a task analysis and obtaining a good understanding of the task(s) a person or team needs to accomplish is important for designing or redesigning the system, the proper environment, technology, training, and allocating functions to human and (or) machine to support safe and efficient completion of the task (e.g., Annett, 2004). For example, task analysis can inform decisions about whether (and for which tasks) training is needed, what the training objectives are, and who the trainees are or should be (Salas & Cannon-Bowers, 2001). In fact, task analysis is said to be the first step in instructional development (e.g., Jonassen, Hannum, & Tessmer, 1989), although companies may also think about retrofitting their learning programs with task analyses (Boehle, 2008). Task analysis methods are furthermore used to investigate and locate errors or areas for potential errors, which is important to ensure safe operations, for example in a process control environment such as a chemical or nuclear power plant. Thus, task analysis is applicable and applied in a variety of settings, such as industry (for system design), government (mostly for military operations), education, as well as research (Diaper, 2004; Jonassen et al., 1989; Redish & Wixon, 2003).

Despite the agreement that task analysis is needed, important, and useful for system design, development of training, and error prediction (e.g., Jonassen et al. 1989; Seamster, Redding, & Kaempf, 1997) there are important issues that have yet to be resolved. The issues relevant for the purpose of this dissertation are the expertise required to perform a task analysis, practitioners' current level of proficiency in performing a task analysis, and what training is available and used to obtain proficiency in performing a task analysis.

Closely related are questions about how to measure quality of a task analysis and the reliability of the task analysis methods. Without consistent understanding of a method, a well-understood procedure, and training, it is difficult to establish good inter-analyst and intra-analyst reliability, which are desired characteristics of a method (Whitley, 2002). The purpose of task analysis is for the task analyst to obtain an understanding of the task (e.g. Kieras, 2004). However, if people other than the task analysis cannot use and interpret a completed task analysis, then the task analysis is restricted in its usefulness, would need to be redone by other people, and may yield a different analysis due to a potentially different understanding of the task. Thus, agreement on the breakdown of the tasks has direct practical relevance because of its consequences in terms of time, money, and recommendations, especially with large-scale projects that require many months to complete.

Problem Space: Functional Task Analysis

The task analysis methods focused on in this dissertation address the functional level of a task, that is, they focus on the task redescription in terms of the *goals* and *subgoals* of a task (i.e., the desired end-states rather than the specific means used to accomplish a task). Task analysis methods at the functional level of a task provide answer to the computational question: “What is the purpose of the task?” (Marr, 1982). This class of task analysis methods that involve understanding and representing a task on the functional level include (but are not limited to) the following: Hierarchical Task Analysis (HTA, Annett & Duncan, 1967), Sub-Goal Template (SGT, Shepherd, 1993), Goal-Directed Task Analysis (GDTA, Endsley, Bolté, & Jones, 2003), and the Abstraction Hierarchy (Abstraction-Decomposition Space, Rasmussen, 1985). The common theme of these methods is that the task of interest is represented as a hierarchy of goals and subgoals.

The primary benefit of a functional task analysis is that decomposition of a task occurs on a high level, which makes the task analysis independent of the technological implementation used to accomplish the goals (e.g., Endsley et al., 2003; Redish & Wixon, 2003). For example, the high-level goals and subgoals involved in communication are the same regardless of whether one chooses to use Morse code, a cell phone, or rotary phone. An understanding of a task that is independent of its implementation allows recycling of the task analysis for multiple implementations providing an economical benefit. Furthermore, system designers can save time by starting from a general task representation and focus on how a task *should* be done, *can* be done, and actually *is* being done to support usage by a variety of individuals with different levels of experience. But what is the current status of expertise, training, and reliability (between and within analysts) of functional task analysis?

Level of Performance

To begin with, too little is known about what people who are experienced with task analysis are doing, how they acquired their expertise, and what expertise in the field of functional task analysis "looks like" (i.e., task analysis products or outcomes). This knowledge gap was noted by the first set of studies investigating training of task analysis, especially for comparing novice performance (Stanton & Young, 1999). The lack of understanding the expertise involved in task analysis is acknowledged, with authors often (colloquially) commenting that performing a task analysis is an art (e.g., Stanton, 2006) and advising practitioners to rely on their experience (e.g., Shepherd, 2001).

One explanation of why authors refer to the art to task analysis is the lack of agreement or clear guidance as to how to conduct the task analysis, although some authors proposed a general strategy (e.g., Redish & Wixon, 2003). Despite, or because of, the wide applicability of task analysis, the general process of conducting it is ill defined, and the problem is exacerbated by the existence of an overall large number of different methods that focus on specific aspects of a task and require their own set of skills. In fact, some authors argued that procedures for conducting a task analysis have to strike a delicate balance between being too structured and restrictive, yet structured enough to provide guidance (Militello, Wong, Kirschenbaum, & Patterson, 2010).

Although better task analyses result when people are more experienced with conducting task analysis (Ainsworth & Marshall, 1998, 2000), it appears that even experienced practitioners and researchers do not always apply the task analysis method (e.g., HTA) properly and in a way, that explores all its benefits (Shepherd, 2001; Stanton, 2006). This illustrates both the need for further understanding of the skills involved in task analysis as well as the necessity for better training of these skills.

Training Methods

There is also little information available on exactly how to acquire the skill of performing a task analysis. One important training tool currently available for task analysis is through the many books and chapters describing the principles, enhanced with some examples of rather complex tasks in a select number of domains such as process control or military operation (e.g., Jonassen et al., 1989; Kirwan & Ainsworth, 1992; Stanton, 2006). Workshops and lectures are available; but they usually cover the area rather briefly and training material is not available publicly. Skill acquisition is thus mostly self-directed and occurs through acquisition of abstract, declarative information, with minimal corrective feedback and on the whole task. What are novices' problems and how can current training methods address these problems?

Only a few studies have investigated how people acquire the skill of performing task analysis and have reported that training time was substantial (months) and reliability between analysts questionable. In the first study of training task analysis, participants received four hours of training on a number of different ergonomics methods in the first of four weeks. HTA was among the methods, and examples of other methods are questionnaire, interview, checklist, and observation. The training was based on tutorial notes and included (a) a method's main principles, (b) a case study example, and (c) some practice time in small groups during which participants exchanged the roles of subject matter expert and analyst. Training did not occur to a predetermined criterion. (Stanton & Young, 1999)

During the second and fourth week, participants completed an analysis of a simple device for which no further detail was given. Measures included execution time and subjective ratings on a number of dimensions that included ease of application and perceived usefulness. Data analysis included intra-rater reliability, inter-rater reliability, and validity – however, the authors did not specify on what basis they evaluated participants' products (i.e., the task analysis output such as an HTA diagram) (Stanton & Young, 1999).

Results showed that HTA was among the methods that took longest to learn and execute with 1 hour to train, 2.5 hours to practice, and on average over 2 hours to apply. This compares to less than 30 minutes for learning and practicing as well as 30 minutes for applying the questionnaire method. Inter-analyst reliability of HTA was low as was the intra-analyst reliability. Thus, about four hours of instruction and practice were clearly insufficient to acquire this skill. HTA was one of the methods for which the authors urged caution when novice analysts are using it (Stanton & Young, 1999).

A different set of studies aimed at specifically investigating whether HTA can be trained by examining the common errors as well as the effects of different types of training on resulting HTA products. In the first study, novice students received declarative training on HTA (five pages outlining the major features of HTA) and then asked to analyze two common tasks: making a cup of tea and painting a door.

Participants first completed task analyses individually and then again in groups. Resulting task analysis products were compared on five criteria derived from HTA (hierarchical, logical decomposition, logical equivalence of decomposition, specification of plans, and stopping rule) and four criteria based on the authors' experience (task boundaries, omitting cognitive goals, operations as activities, and versatility of analysis). Students had serious problems with all criteria and were rather unaware of their difficulties as evidenced by questionnaire data (Patrick, Gregov, & Halliday, 2000).

In a second study, the authors compared four experimental groups that differed in the types of training they received. One group received the same five-page handout as in the previous study. The remaining three groups received additional training that can be described as declarative vs. procedural training and a combination of both. The declarative training (i.e., memorizing a sequence of high-level goals) did not yield better task analyses than the initial training (i.e., the five-page instructional handout). Either of the two training conditions that included procedural training was associated with higher scores on the coding criteria. Procedural training included working through correct and incorrect examples as well as providing students with feedback on their task analysis performance. However, conclusions that can be drawn from these results are limited because the four training conditions differed in length and whether participants received feedback. Nevertheless, the findings provide valuable insight into the nature of problems that students had when learning HTA (Patrick et al., 2000)

The above illustrates that there are obstacles to overcome in training functional task analysis. Deliberate practice (Ericsson, Krampe, & Tesch-Römer, 1993) may be a solution, but a novice still requires specific information about what to practice. Thus, a better understanding of the skill of functional task analysis and its acquisition is needed, and this can be obtained by both assessing current practices and investigating novice performance.

Caught in a Recursive Loop

A task analysis of a task analysis is needed to add rigor to a method of the human factors trade. Patrick et al. (2000) acknowledged the appropriateness of starting the design of training with a task analysis, in case of HTA that would be a task analysis of HTA, yet argued against such an approach because it would only yield high-level goals/objectives. Moreover, the authors stated that such expertise would be difficult to extract, differ between analysts, and not generalize to different tasks (thus, be task specific). A comparison of just six different task analysis methods showed how diverse the required expertise between these methods (Adams, 2008). How then to break this loop and understand task analysis itself?

Demystifying The Art to Task Analysis

Using the metaphor of "the art of task analysis" can imply two things. One interpretation is that task analysis is something one either does or does not know how to do, and that nothing really can be done to acquire it. Here, the connotation of art is in the sense of "a personal, unanalyzable creative power" (Merriam-Webster, 2009). This dissertation is based on a second interpretation, namely one that is based on the understanding of art as a "skill acquired by experience, study, or observation" (Merriam-Webster), and thus the scientific method can be employed to understand and train that skill.

Understanding Task Analysis as a Skill

This dissertation is based on the assertion that if task analysis is the first step in developing training material, then an analysis of task analysis is needed. It does not sound probable that a task analysis method needs to be learned anew for each task and task domain; thus, the task analyst can be assumed to have acquired general task analytic skills. The 4C/ID-Model (four components, instructional design) outlines four layers of activities involved in developing training for complex cognitive skills. The first layer is a principled skill decomposition, that is, creating a hierarchy of constituent skills (van Merriënboer, 1997). Therefore, the overarching question is what components skills underlie task analysis?

Functional Task Analysis as a Skill

Fleishman (1972) defined skill as the "level of proficiency on a specific task" (p.1018), attained mostly through practice although other factors (e.g., feedback) also play a role (Rosenbaum, Carlson, & Gilmore, 2001). Skills have been characterized as encompassing a wide variety of behaviors, being learned, and consisting of different proportions of motor, perceptual, and cognitive components (Adams, 1987).

Generally, the skill of performing a task analysis can be described as a complex cognitive skill (Patrick et al., 2000), with cognition playing a major role and motor control playing a minor role. This dissertation is based on the assumption that acquiring skills to perform a functional task analysis is not fundamentally different from any other cognitive skill and that principles and theories of skill acquisition can be used to understand the skills involved in performing functional task analysis.

As a complex skill, functional task analysis can be expected to take at least 100 hours to acquire (Schneider, 1985) which stands in contrast to the maximum 4 hours of training provided by the training studies reviewed (e.g., Patrick et al., 2000; Stanton & Young, 1999). At least 10,000 hours of deliberate practice may be expected to reach a high level of proficiency or expertise (Ericsson et al., 1993), which translates to about 5 years with a typical 40-hour work-week solely devoted to the task being practiced.

Levels of Proficiency

To understand the problem space of a skill, it is important to describe and investigate performance at various levels of experience (Adams, 1987). Stage models have been suggested that provide labels for classifying various levels of proficiency. For example, five stages were suggested by Dreyfus and Dreyfus (1980), with a progression from 1) novice, 2) competent, 3) proficient, 4) expertise, to 5) mastery. These five levels are based on a change in one of four dimensions of mental activity: recollection (non-situational to situational), recognition (decomposed to holistic), decision (analytical to intuitive), and awareness (monitoring to absorbed).

Changes in performance that are associated with changes in the level of proficiency have been documented for a variety of skills (e.g., see Adams, 1987 for motor skills), provided there is consistency in the information to be processed (e.g., Fisk, Ackerman, & Schneider, 1987). Novice performance is mostly measured in terms of accuracy and speed to obtain baseline performance, and typical errors are captured as well. Once performance has been practiced and learners exposed to a variety of examples, other measures are added to determine transfer of the acquired skill to new tasks and problems (e.g., Adams).

Performance during skill acquisition is not equally well predicted by the same variables. Different individual variables have been found to best predict performance during the three phases of skill acquisition. Performance in the first phase of skill acquisition (cognitive or declarative phase) is best predicted by general abilities such as working memory capacity and reasoning ability. Performance in the second phase is best predicted by perceptual speed and the third stage of skill acquisition mostly by psychomotor speed (Ackerman, 1988). This illustrates that performers at different stages of skill acquisition experience different challenges, and that it is necessary to understand performance at all levels of proficiency.

Superior expert performance is not always easy to define or quantify. Criteria such as a certain amount of practice, experience, education, and reputation do not guarantee superior performance (Ericsson, 2006). Although superior performance is not always observable, it is possible to capture and define the nature of such performance and define performance criteria (Feltovich, Prietula, & Ericsson, 2006). In fact, task analytic methodology is generally employed to determine the rule-structure of skilled performance that is then taught to the learners so they can focus on internalizing this structure instead of having to generate it themselves (Patrick, 1992).

To understand levels of skilled performance it is furthermore important to identify consistent components of a task. Mere practice is not sufficient to improve performance; other variables have to be factored in as well. For example, the consistency of task components is important for the development of automaticity (e.g., Fisk & Eggemeier, 1988). It is currently unknown what these components are for task analysis, and without knowledge of the components it is not possible to propose a model of the skill. One contribution of this dissertation is to help identify what components make task analysis a skill. This will aid the definition of what expertise in this domain means.

Stages of Skill Acquisition

Building on the proposed stages of skill acquisition (Fitts & Posner, 1967), Anderson (1982) viewed skill acquisition as moving from a declarative stage (knowing what) to a procedural stage (knowing how to). In the declarative stage, factual (declarative) knowledge is acquired, exists in form of a propositional network, and is applied by a mechanism of interpretation. Performance in this stage is error prone and slow because facts have to be encoded, retrieved, held in working memory or they are quickly forgotten. A person moves to the procedural stage through a process of knowledge compilation (Fitts' associative stage) during which procedural knowledge is created in form of productions, that is, if-then else rules. New productions are created through associations in declarative memory; however, if productions already exist, then these are being used and updated if necessary. This is important because the knowledge that a novice brings to the task may conflict with knowledge that is required for the task – a conflict that can be detected. Knowledge in the procedural stage exists in the form of such productions (procedural knowledge), and performance in the procedural stage is fast, and knowledge application occurs through retrieval of appropriate procedures.

Current training methods of functional task analysis can be viewed to build on one or both of two possible underlying assumptions. One assumption is that compiling the knowledge is a trivial matter, and that it is "easy" for novices to create the respective productions from declarative knowledge. The second assumption is that it is appropriate for novices to draw on already existing procedural knowledge (productions) to perform a functional task analysis.

However, research suggests that knowledge compilation for functional task analysis is not trivial (e.g., Stanton, 2006) and procedural knowledge that novices bring to the task of performing a functional task analysis may even be counter to that required by functional task analysis (Patrick et al., 2000). More specifically, one critical and difficult component involved in functional task analysis is the hierarchical decomposition in terms of goals and subgoals. Novices trained in HTA tended to break down the task in terms of specific actions used to accomplish a goal rather than into goals and subgoals that are to be accomplished (Patrick et al.).

Two common challenges found with Goal-Directed Task Analysis relate both to delineating goals. One challenge was delineating goals from tasks (actions), and the other was delineating goals from information requirements (Endsley et al., 2003). This shows that identifying and breaking down goals into subgoals is difficult for the novice and suggested to be counter to more common ways of thinking and analyzing, such as temporal order, kinds-of hierarchy, or prerequisites (cf. Patrick et al., 2000).

Chapter Summary

Currently, the skill of functional task analysis is underspecified and existing training methods are not sufficient to move learners from the declarative to the procedural stage. The following chapter provides an overview of two studies that were conducted in parallel to obtain insight into the skill of functional task analysis. General themes of the two studies are integrated in the general discussion.

CHAPTER 2: OVERVIEW OF THE STUDIES

The overall goal for this dissertation was to explore the skill components involved in functional task analysis. The review of research and training methods revealed a knowledge gap with respect to the skill of functional task analysis. This chapter provides an overview of the two studies conducted to address this knowledge gap, the tasks used for studies, and the data analyses employed.

Study 1: Experienced Task Analysts

The primary goal of the first study was to capture and characterize experienced performers' task analysis products and process. Helpful in providing such information is the first of three steps of the expert performance approach: Develop an understanding of the nature of the expertise by capturing stable, superior performance (Ericsson & Smith, 1991). Participants in this study were professionals who are experienced with task analysis because it is not known who the "experts" in functional task analysis are. Participants conducted six task analyses while thinking aloud. Questionnaires and a structured interview followed to elicit further information about the process of conducting task analysis.

Task analyses that professionals produced in the context of the study were analyzed for common characteristics: the dimensions of the task analysis hierarchy, the focus of subgoals, and the versatility of the task analysis product. Furthermore, the process of conducting a task analysis was characterized in terms of the overall approach, questions, and assumptions through examination of the think-aloud data. Together these findings will shed light on the characteristics of experienced task analysts' performance. The specific questions were:

- What are the dimensions of the hierarchy (depth and breadth)?
- What subgoals do professionals' focus on?
- Are professionals' task analysis products versatile?
- Do participants employ a breadth-first or depth-first approach?
- What questions do professionals ask?
- What assumptions do professionals make?

Study 2: Novices learning HTA

Study 2 focused on novices performing task analyses with the goal to capture and characterize novices' untrained performance and assess the procedural and declarative knowledge novices acquired through brief training. Undergraduate students at the Georgia Institute of Technology first conducted a task analysis before receiving general instructions about a common form of functional task analysis (Hierarchical Task Analysis). Novices also received additional instructions specific to their training condition. They analyzed five additional tasks before completing two questionnaires whose purpose was to collect task familiarity information, assess declarative knowledge about the main features of HTA, and collect data about the difficulty of applying the method and strategies used.

The task analysis products provided a basis for assessing procedural knowledge developed in this initial phase of skill acquisition, and the questionnaire data were analyzed for the declarative knowledge. The data will provide valuable information about how novices approach the task of performing a functional task analysis, their errors and misconceptions, and how these vary as a function of instructional material. The specific questions were:

Procedural knowledge:

- What are the characteristics of untrained performance in task analysis?
- What are the characteristics of minimally trained performance in task analysis?
- Are participants able to spontaneously generate the required procedural knowledge based on brief, declarative training?
- What features of HTA improved?
- What are novices' errors? (procedural knowledge)
- Does performance differ as a function of training condition?

Declarative knowledge

- What content did novices learn?
- What were novices' misconceptions?
- Does performance differ as a function of training condition?

Tasks to Be Analyzed

Goals for Task Selection

The task space was sampled, but not exhaustively. Generally, a task was defined as a problem to be solved and included goals and constraints (Shepherd, 2001). There were four requirements for task selection. First, the goal was to gather a number of performance measures from each participant and thus ask participants to analyze more than just one or two tasks as was done previously (e.g., Patrick et al., 2000). Secondly, tasks should be representative of relevant aspects of the tasks that professionals encounter in their everyday work. The tasks selected for this dissertation are likely to be of smaller magnitude than what some professionals encounter in their work, given that professionals sometimes work for months and years on just one task analysis. However, the tasks were expected to be representative in important task dimensions, such as having a goal that is to be accomplished and that can be redescribed into subgoals, requiring sensation, perception, cognition, and action; having inputs, outputs, and feedback; and having a discernable order or inner task structure. Thus, the tasks were expected to provide sufficient context to elicit the desired information about conducting a task analysis and allow generation of a task analysis product. Information about typical tasks that professionals analyze was gathered in the Demographics and Experience Questionnaire.

A third goal was to simulate a scenario in which task analysts have some prior knowledge available, either by having previously analyzed tasks in a domain or by using information from documents and their experience to draft a task analysis for discussion with subject matter experts. Common tasks would fulfill this requirement. Common tasks would also be beneficial for novice task analysts. A novice task analyst who is required to both learn about a domain as well as how to conduct a task analysis can be assumed to have a very high intrinsic cognitive load, that is, a high degree of complexity due to the nature of information to be learned (cf. Carlson, Chandler, & Sweller, 2003). Choosing familiar tasks (or domains) reduces this intrinsic cognitive load and allows participants to focus on learning how to conduct the task analysis without having to learn about a new domain or extract information from subject matter experts

Lastly, the tasks should be simple enough to allow participants to conduct a task analysis within a short time frame (15 minutes), which is representative of a learning situation when novices first encounter task analysis with an example.

Tasks

The task to be analyzed was a within participant variable, and participants in both studies analyzed the same tasks (see Table 2.1). The tasks were drawn from two domains: cooking and communication, and three tasks were selected for each domain; thus, participants conducted six task analyses overall (see Appendix A.1 for stimulus material). Tasks were arranged in two counterbalance versions based on a fixed task order (specific-familiar, general-familiar, specific-unfamiliar) and counterbalanced domain order.

Table 2.1

Overview of Tasks to be Analyzed

Domain	Familiarity	Specificity	Task
Cooking			
	Familiar	Specific	*Making* a peanut-butter jelly *sandwich*
	Familiar	General	*Making breakfast*
	Unfamiliar	Specific	*Making Vetkoek* (a South African main dish)
Communication			
	Familiar	Specific	*Making* a *phone call*
	Familiar	General	*Arranging* a *meeting*
	Unfamiliar	Specific	*Sharing pictures* using Adgers (a communication software)

Note. In the remainder of this document, the tasks will be referred to by their shortened version as indicated in italics or by the following nouns: sandwich, breakfast, Vetkoek, phone, meeting, and Adgers.

The final tasks were selected based on their use and mentioning in previous studies (e.g., Craik & Bialystok, 2006; Davis & Rebelsky, 2007; Patrick et al., 2000; Shepherd, 2001) and so tasks covered a range of participants' expected degree of familiarity (low, high) and the level of specificity of the procedure (low, high).

Familiar tasks were those commonly completed in the USA and thus be part of the common knowledge. Because familiarity with the procedures of a task might affect accessibility of task-related information and influence the resulting task analyses (Patrick et al., 2000) each domain received an additional task that was unfamiliar. An unfamiliar task means that task-specific information (e.g., procedural steps) is unavailable, and participants would be required to draw on conceptually higher-level task knowledge.

Tasks were also differentiated on the level of specificity. Specific tasks were chosen because of their usage in previous training studies (e.g., Patrick et al., 2000). A general task was chosen as a complement and defined in that it had fewer constraints and required more choices. Because specific procedural details were available, task analyses of specific tasks were expected be more detailed and tied to a technological implementation. Tasks that included more choices should be associated with more general task analyses because the analysis needs to include a variety of procedures.

Overview of the Data Analyses

Master Task Analyses

To assess task analysis products, two coders created a master task analysis for each task as a solution to compare participants' task analysis against (see Appendix A.2). The master task analyses were informed by published work (e.g., Felipe, Adams, Rogers, & Fisk, 2010; Patrick et al., 2000) and task analyses gathered from volunteers. Two coders combined the information and agreed on a master task analysis. The master task analyses followed the recommendations for numbering (Shepherd, 2001; Stanton 2006). A subgoal was operationally defined as a verb-noun pair (e.g., take order), and the placement within the hierarchy indicating the super-ordinate or sub-ordinate status. The implication is that a super-ordinate status indicates a goal and sub-ordinate status an action to accomplish that goal. Thus, this dissertation takes a contextual definition.

Furthermore, literature provides a number of rules of thumb as to the number of subgoals making up one level. The breadth was suggested to be 4 to 5 elements broad (Stanton & Young, 1999), between 4 and 8 followed by the recommendation to look for super-ordinate goals when there are more than 10 elements (Patrick, Spurgeon, & Shepherd, 1986, as cited by Stanton, 2006), no more than 7 (Ainsworth, 2001), or between 3 and 10 (Stanton, 2006). A minimum breadth of three and a maximum breadth of eight elements at the highest level were chosen because these numbers were most consistent with all the recommendations.

Statistical Analyses

Participants' task analyses, questionnaire answers, and think-aloud data were analyzed quantitatively and qualitatively. Unless otherwise noted, two coders performed the qualitative data analyses, blind to the assignment of training condition or counterbalance order. Coders established inter-rater reliability, continued to code all data, and disagreements were resolved through discussion. A satisfactory reliability was Cohen's Kappa (K) greater than .8 (Landis & Koch, 1977). Chi-square analyses on the resulting counts determined whether observed differences were significant. Analysis of standardized adjusted residuals determined what categories contributed most to the significant effect, the criterion being a residual of greater than 2.0 (Haberman, 1973). A repeated measure ANOVA helped determine significant differences in breadth and depth of task analyses. The non-parametric Friedman test was used where appropriate, with Wilcoxon signed rank test for follow-up comparisons.

CHAPTER 3: EXPERTISE IN FUNCTIONAL TASK ANALYSIS

Some generalizations about the declarative and procedural knowledge involved in task analysis can be derived from literature. This chapter aims to describe the nature of expertise involved in functional task analysis by examining relevant literature and tools designed to support task analysis.

Phases of Task Analysis

Three general phases involved in task analysis have been identified: planning for the task analysis, collecting task analysis data, and analyzing and presenting the data (Redish & Wixon, 2003). The first phase of planning for task analysis includes being signed into the project plan, understanding what data the project team needs, when those data are needed, determining the purpose of the task analysis, setting the scope of the task analysis (e.g., level of detail), and generally understanding the user of the task analysis data. The second phase, collecting task analysis data, mainly occurs through observation and interviews of subject matter experts. Thus, declarative knowledge about the benefits and limitations of these data collection methods is needed, knowing how to sample users and environments, and how to conduct field and lab studies. Clearly, the task of task analysis is complex and consists of many elements. To limit the scope of this dissertation, the phases of planning and collecting data or drawing inferences from task analysis data in form of recommendations were not emphasized.

Instead, the focus of this dissertation was on the third phase in which task analysis data are analyzed and presented. In this phase, data are thought about, condensed, and made useful. Task elements (e.g., goals and subgoals) are identified and their relationship noted. Literature also provides recommendations about involving the design team to create a shared understanding, maintaining traces from the analyzed data to the underlying raw data, making information accessible (not hiding it in a huge report), and matching the presentation format to the question currently being answered (Redish & Wixon, 2003). How this process proceeds, however, is not further specified. Nevertheless, it becomes clear that there are three important goals that are to be accomplished in this phase: understanding the task (on whatever level of analysis it is defined), obtaining a shared understanding with project team members, and generating diagrams to support subsequent design decisions.

The task analysis process model by Ainsworth (2001) differentiates six stages: Plan and prepare, collect data, organize data, analyze data, produce report, and verify. Ainsworth emphasized that the skill of interpreting task analysis data is important. However, given that novices' have problems when still extracting and organizing data (Patrick et al., 2000), the focus of this dissertation was on the stage during which data are organized, and more specifically, when task descriptions are developed and a task is broken down into goals and subgoals and a task hierarchy created. This aspect of breaking down goals into subgoals is described as "difficult" (e.g., Patrick, 1992); however, not much knowledge of the underlying skill components is available.

Support Tools

Another approach to learn about the skill of functional task analysis is to examine the tools that have been created to support task analysis and understand which parts of the task analysis process these tools are supporting. Software tools such as the commercially available software TaskArchitect for HTA have been developed to help the task analyst in the task analysis process. Thus far, such a tool supports the documentation and presentation aspect of task analysis by providing a template to be filled in and automatically transformed the data into a diagram format. This is immensely beneficial for managing and presenting large amounts of task analysis data, which means that keeping track and managing extracted data about a task is an important aspect in the task analysis process. What a software tools like TaskArchitect does not solve, however, is the extraction of the respective data. The task analyst is still required to determine which data to enter into the software program.

The subgoal-template (SGT) (Ormerod & Shepherd, 2004) is a tool that was created to help the task analyst with HTA. SGT is intended to help by providing the task analyst with a set of basic elements (see Table 3.1) From the focal points of SGT it is possible to derive two general task analysis problems. The first issue is the stopping rule, that is, determining when to stop redescription of a task. SGT provides a clear rule: A path of a task analysis stops when the level of the basic elements has been reached. The second issue is then identifying the basic elements of a task, and doing so with a consistent label).

Table 3.1

Subgoal-Template Task and Sequencing Elements (from Ormerod, Richardson, & Shepherd 1998)

Code	Label	Task Types/Syntax
Task elements		
A	Action	Activate (A1), Adjust (A2), De-activate (A3)
C	Communication	Read (C1), Record (C2), Wait for information (C3), Receive information (C4), Give information (C5), Remember (C6), Retrieve (C7)
M	Monitoring	Monitor to detect deviance (M1), Monitor rate of change (M2), Inspect plant and equipment (M3)
D	Decision	Diagnose process problems (D1), Adjust plan (D2), Locate contaminant (D3), Judge adjustment (D4)
Sequence elements		
S1	Fixed	*S1 Then X*
S2	Contingent	*S2 Either* Z *Then X Or* not *Z then* Y
S3	Parallel	*S3 Then do together* X *and* Y
S4	Free	*S4 In any order* X *and* Y

Although the above mentioned tools attempt to formalize and provide help with difficult aspects of conducting a task analysis, they do not solve the underlying problem of redescribing a task into its elements. As Figure 3.1 illustrates, selecting and assigning a basic task element of SGT (a right loop in the figure) only solves part of the redescription problem. The task analyst still needs to know how to properly redescribe when no basic element is available from the template that fits the current situation (a left loop in the figure).

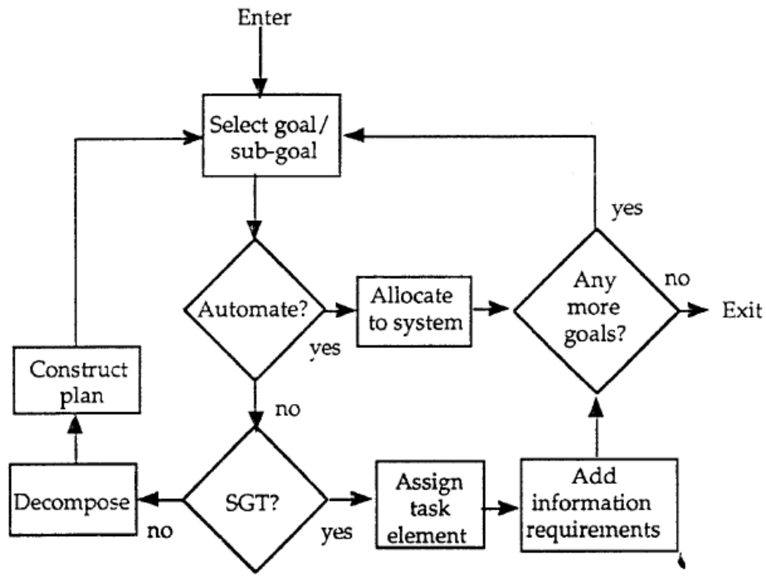

Figure 3.1. The design cycle underlying the subgoal-template method (from Ormerod, Richardson, & Shepherd, 1998).

Drawing from difficulties about conducting a task analysis outlined above, the following can be extracted as potential skill components of functional task analysis pertaining to the phase of task (re)description: identify the subgoals (redescribed goal into subgoal), determine subgoal label, determine the hierarchical arrangement, and determine when to stop (depth of analysis). Drawing from previous studies on training functional task analysis (Patrick et al., 2000; Stanton & Young, 1999), this list can be amended by: delineating goals from actions (and information requirements), differentiating subgoal content from the sequence of accomplishing subgoals, and determining the boundaries of the analysis in breadth (what subgoals to include and exclude), and lastly creating a hierarchy.

Identifying Subgoals

Employing functional task analysis methods requires the representation of a task, with the task described in terms of its goals. Conceptually, a *goal* can be described as a desired end state and delineated from an *action* which is the means to reach this end state. The goal is the focal point around which behavior is organized and can vary in abstractness (Austin & Vancouver, 1996). In the seven stages of action cycle brought forward by Donald Norman (1998), people get things done by first forming a goal, which is followed by forming an intention, specifying the action, executing an action and three stages of evaluating the outcome, which complete the cycle by referring back to the formation of the goal.

Goals are highly researched in psychology (for a review see Austin & Vancouver, 1996; Gollwitzer & Moskowitz, 1996), and a wide range of definitions and theories on various aspects of goal formation and content have been developed over time. Despite many conceptual definitions, the practical delineation of goals from actions is problematic. One reason is that the boundary between where a goal ends and an action begins is blurry and not clearly defined, and thus confusion as to what exactly constitutes or qualifies as a goal and what constitutes an action is inevitable (Austin & Vancouver).

This confusion surrounding the delineation of goals from actions in task analysis, prompted some authors to suggest abandoning the concept of goals from task analysis altogether (Diaper & Stanton, 2004). Unclear definitions can have potentially negative implications for the reliability of the task analysis product, and in practice, it has been noted that it is possible that the task analyst wrongly focuses on the actions rather than the goals at which the actions are aimed (Patrick, 1992). An ill-defined distinction of goal and action poses a challenge for conducting a task analysis, especially for the novice who has to develop procedural knowledge about how to conduct a task analysis (Endsley et al., 2003; Patrick et al., 2000). Unclear definitions also pose a problem when designing training materials. The above illustrates the importance of clear definitions and shows that the boundary between goal and action are blurry, leaving the question how experienced task analysts resolve this ambivalence.

Potential Strategies to Task Analysis

Two possible approaches to task analysis are debated and differentiated based on whether a task analyst chooses to first analyze the breadth or the depth of a task (Jonassen, Tessmer, & Hannum, 1999). Analyzing the breadth of a task first involves drawing down the major task subgoals on the highest level of analysis to outline the lay of the land, so to speak. For example, a participant may list the high-level subgoals of *making sandwich* as “gather ingredients”, “gather dishes”, “combine ingredients”, “serve”, and “enjoy”, before detailing that “gather ingredients” means to “select ingredients”, “locate ingredients”, and so on. Conversely, an analyst who chooses to go depth-first, will identify the first high-level subgoal and redescribe into its component subgoals before moving on to the next subgoal on the highest level. For *making sandwich*, one would state the first high-level subgoal of “gather ingredients” and immediately specify that this mean to “select ingredients”, “locate ingredients” and so forth before moving on to the next main level subgoal of “gather dishes”.

Another strategy found in literature is to ask questions to guide the task analysis process; however, there is a variety of suggestions. Two general questions are meant to guide the instructional designer during the principled skill decomposition phase. “Which skills are necessary in order to be *able* to perform the skill under investigation” (van Merriënboer, 1997, p. 86) are meant to elicit elements on a lower level in the hierarchy, and “Are there any *other* skills necessary to be able to perform the skill under consideration" (p. 87) help elicit elements on the same level in the hierarchy. Stanton (2006) compared different lists of questions that vary based on the problem domain a task analyst is working in. Because the questions suggested by Ainsworth are most general, the coding scheme was based on six questions meant as a guide through task analysis: who, what, where, when, why, and how, but without further specification as to when to ask these questions or how they inform the task analysis.

Assumptions can be viewed as the flip-side of questions, namely when analysis has to progress but there is nobody to answer questions. Furthermore, stating assumptions is an important part of the analysis because it helps understand the limitations and applicability of the analysis (Kieras, 2004). Thus, it was of interest if experienced task analysts did indeed make assumptions, and if yes, what those were.

Benefits of Studying Experienced Performers

Much can be learned by studying experienced performers. The first in a three-step process of studying experts is to capture stable and superior performance (Ericsson & Smith, 1991). This first step means collecting information about the expression of the skill, what the skills looks like, what shapes and forms it takes. To understand a skill, it is important to obtain a picture of what experienced performers are actually superior in and to what stimuli and circumstances the skill applies. Studying experienced performers brings about information about the goals of skill development, and the benefits of knowing goals have been shown to be an important factor in training (e.g., Adams, 1987). Knowing where one is headed not only provides direction, but also constitutes a metric against which to compare current performance and allows adjusting the course.

Background to Methodologies Employed in Study 1

To gather information about characteristics of experienced task analysts' products and process, participants in study 1 conducted task analyses while thinking aloud protocol, and completed questionnaires and a semi-structured interview.

Concurrent Think-Aloud Protocol

Employing a think-aloud protocol allows participants to express thoughts that are not accessible to the experimenter via observation. Data obtained from the think-aloud protocol are limited to information that is available for verbalization, and this dual task situation may limit the resources that are available for conducting the task analysis. However, task analysis is by nature an analytical task and thus compatible with the analytical mode that the think-aloud protocol elicits (cf. Hammond, 1996).

Questionnaires

The questionnaires collected data in a condensed, quantitative format. The goal was to gather data about participants' task analysis experience and focus, familiarity with the tasks to be analyzed, along with obtaining information about the task analyses that participants conducted in the study.

Semi-Structured Interview

The semi-structured interview allowed targeting specific questions about participants' experience with task analysis while also having some flexibility to follow-up with questions. Questions and format were based on Applied Cognitive Task Analysis (Militello & Hutton, 1998) and Critical Decision method (Klein, Calderwood, & MacGregor, 1989) and combined with a sunshine scenario (a task analysis gone well) followed with a worst case scenario (a challenging task analysis).

Number of Participants

There are no hard and fast rules for determining the number of participants in an exploratory, qualitative inquiry (Krueger, 1994), and it is often a matter of experience (Sandelowski, 1995). Typical sample sizes range between 5 and 20 units of analysis (Kuzel, 1999). No fewer than three subject matter experts are recommended for the knowledge extraction process proposed by Fisk and Eggemeier (1988). Some variation between participants' approach to task analysis were expected, given the large number of task analysis methods. The final number of participants was determined by multiplying a lower number of participants with the number of task counterbalance version (two).

CHAPTER 4: STUDY 1 - METHOD

Participants

Eleven professionals participated in this study. However, the data from three participants were excluded from data analysis. Because of a technical failure the think-aloud protocol of one participant was not recorded. Another participant did not complete the interview. The third participant's data were excluded from data analysis because one task analysis was spoken and not written. The study lasted approximately 3 hours, and participants received a $50.00 honorarium for their participation.

Four of the eight professionals included in data analysis participated in Atlanta, Georgia, and four participated in Raleigh, NC. Participants' (2 male, 6 female) age range was 27-54 years (*M*=39, *SD*=8.6). Five participants described themselves as White Caucasian, one as Black/African American, one Asian, and one American Indian/Alaska Native. All spoke English as their native language.

Six of the eight participants indicated a master's degree as their highest level of education. The majors ranged from Industrial Engineering, Biomedical Engineering, Industrial Engineering, Instructional Design, Rehabilitation Counseling, and Occupational Ergonomics. One participant's highest level of education was a Bachelor in Occupational Therapy, and one participant's highest level of education was a doctorate in Psychology.

Three participants were a Certified Professional Ergonomist (CPE), one of these participants also having a second certification as an Industrial-Professional Engineer (PE). One participant was a Licensed Occupational Therapist.

Selection Criteria: Prior Experience with Task Analysis

Participants were selected based on their experience with task analysis, operationally defined as number of years involved in conducting task analysis and recency of such involvement. Experience with specific task analysis methods was not required because professionals might use different labels for the task analysis method they employ. To increase the breadth of the sampled data, participants were recruited from different companies because participants working in the same organization were likely to use a similar approach to task analysis.

More specifically, there were four inclusion criteria. Firstly, participants needed to be native English speakers. Secondly, participants had to use task analysis for their job rather than, for example, a school project. Thirdly, participants were required to have had at least two years experience conducting task analysis. In this time frame, participants were expected to have experienced some breadth in their task analysis work. Lastly, participants must have worked on at least one task analysis in the past year to ensure that their experience with conducting a task analysis was recent (see Appendix B.1 for recruitment questions).

Recruitment

Participants were recruited from Atlanta (Georgia) and Raleigh (North Carolina) via professional organizations that were likely to have members who use task analysis: Human Factors and Ergonomics Society, Special Interest Group on Computer-Human Interaction, and the Instructional Technology Forum. Furthermore, local companies, organizations, and professionals in the greater Atlanta and Raleigh area were approached if they were known to use task analysis. Lastly, the database of the Board of Certification in Professional Ergonomics served as a resource for participants. Members were contacted for their interest in participation if their self-designated area of expertise was either “Job/task analysis” or “Job/task analysis & design”.

Materials

Questionnaires

Participants completed three questionnaires over the course of the study. The Demographics and Experience Questionnaire (Appendix B.2) assessed information about age, gender, educational background, and certifications. Participants indicated their experience with task analysis, that is, how many task analyses they have completed in their professional life, and how many of them in the past year. Questions included for what purposes and goals participants used task analysis, and what aspects of a task they emphasize in their analysis. Participants were asked to list the task analysis methods they used, how often they used them, when and how they learned each one, and to rate their proficiency with the methods listed; the same questions were then asked for a number of commonly known task analysis methods.

The Task Questionnaire (Appendix B.3) required participants to rate their familiarity with each task they analyzed in the study and the frequency of performing those tasks in their everyday life. The Task Analysis Questionnaire (Appendix B.4) asked participants to describe the main features of the task analysis method they just used. It also asked participants to rate how difficult they perceived the task analysis to have been, how confident they were in their analysis, how representative their task analysis was in comparison to what they normally did in their job, and how they broke down the task. Seven specific questions followed about the task analyses participants just performed: what was easy, difficult, how they identified goals and subgoals, indicated order, decided on breath and depth of the analysis, and what elements to analyze further.

Instructional Scenario

To set the context for the study's task analyses, participants received instructions in the form of a paragraph-long scenario (see Appendix B.5 for specific wording). The scenario instructed participants to imagine a situation in which they had just joined a new team. To create common ground, the new team members were asking the participant to share and illustrate his/her understanding of task analysis on a number of example tasks.

Tasks to be Analyzed

The details and justifications for the tasks were presented in Chapter 2. To summarize here, tasks were drawn from the two domains cooking and communication. The tasks of the cooking domain were *making a peanut-butter jelly sandwich*, *making breakfast*, and *making Vetkoek (a South African main dish).* The tasks of the communication domain were *making a phone call*, *arranging a meeting*, and *sharing pictures using Adgers (a communication software).* Half of the participants received cooking tasks first, the other half received communication tasks first. Task order within each domain was fixed.

Semi-Structured Interview

Questions of the semi-structured interview aimed at eliciting information about three general topics (see Appendix B.6). The first topic probed participants about the challenges of task analysis in general, becoming proficient at it, and participants' definition of expertise in task analysis. The second topic consisted of six questions related to task analysis products as well as typical tasks. The third topic area included three questions about participants' general process of task analysis.

Following these questions, participants were instructed to think of a task analysis (or part of a task analysis) that went well and participants were pleased with the outcome ("sunshine scenario"). A set of 12 short questions followed with the goal of eliciting procedural and strategic information. Following the sunshine-scenario, participants were asked to think back to a task analysis or part of a task analysis that was challenging while answering the same questions. The experimenter asked participants to elaborate if their answer was unclear or they used terminology that was potentially ambiguous.

Equipment and Set-up

Participants conducted their task analyses on 11 x 17 inch, off-white paper, placed in landscape format in front of them. Participants were free to use as many pages as they needed and reposition the paper in a format they preferred, while keeping within a constrained space that the cameras captured.

An Olympus DM-10 voice recorder recorded all interviews, before their transfer to a PC, and conversion to mp3 format for transcription. Two QuickCam web cameras (Logitech, 2007) captured participants' hands and workspace from two different angles while participants completed the task analyses (see Figure 4.1 for the basic study setup, illustrated by the Atlanta location). The recordings were stored on PC using Morae Manager 3.0 software (TechSmith, 2009).

Figure 4.1: Setup of study 1 in Atlanta (participant is sitting on the left side).

Design and Procedure

This study had a within-in participant design (repeated measures) as participants analyzed six tasks, arranged in two counterbalance versions (see Chapter 2). An overview of the protocol is shown in Appendix B.7. The general flow of the study outlined in Figure 4.2. Participants read and signed the informed consent form (Appendix B.8) before the experimenter collected the Demographics and Experience Questionnaire that was mailed to participants prior to the study. Following this, participants were oriented as to what information the two video cameras captured before the video recording began. When participants did not have any further questions, then video recording began.

First, participants were given time to get used to being videotaped and thinking aloud by playing tic-tac-toe with the experimenter. Then, participants read the scenario, in which they were asked to illustrate their understanding of task analysis on a number of example tasks. If participants had questions, they were told to do what they would normally do in such a situation. Participants then received a task to be analyzed, printed on a piece of paper, and asked to perform a task analysis while thinking aloud. Participants had 15 minutes to complete each task analysis and instructed to put down their pen or pencil to indicate that the task analysis was completed. The experimenter then collected the task analysis and provided the next task for analysis.

After three tasks, participants took a 5-minute break and were reminded of the instructions and thinking aloud before continuing with the remaining three task analyses. Participants then completed the Task Questionnaire and Task Analysis Questionnaire, and took a 10-minute break before starting the semi-structured interview. Another 10-minute break was given every half hour during the semi-structured interview. Lastly, participants were debriefed (see Appendix B.9), thanked, and paid for their participation.

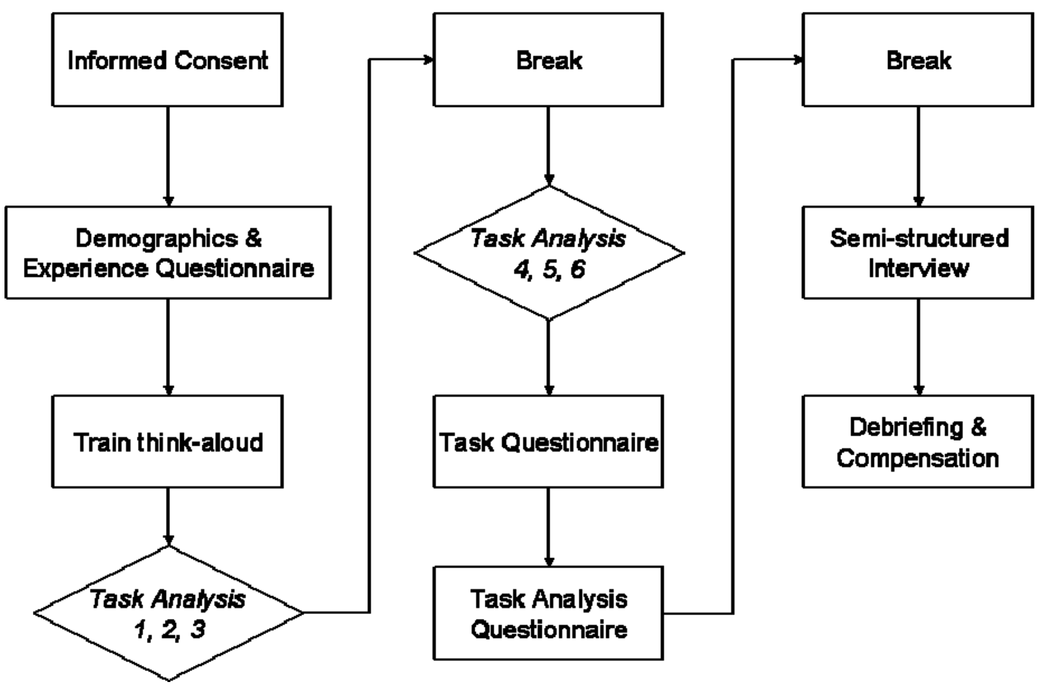

Figure 4.2: Flow of activities in study 1

CHAPTER 5: STUDY 1 – DATA ANALYSIS AND RESULTS

Analysis of data gathered in this study focused on three areas. First, the professionals' experience and proficiency with task analysis was collated to understand participants' background. Secondly, participants' task analysis products were examined to determine product characteristics (hierarchy dimensions, subgoals, versatility). Thirdly, participants' think-aloud protocols and interviews were analyzed for process characteristics (breadth or depth-first, questions, and assumptions).

Experience and Self-Rated Proficiency

The Demographics and Experience Questionnaire included questions about participants' experience with task analysis: Participants' experience with task analysis in general, what tasks they analyze, and what aspects of a task they emphasize in their task analysis. These data were analyzed as a check that participants fulfilled the requirements for inclusion in data analysis and to provide a description of the sample.

A Range of Experience with Task Analysis

The Demographics and Experience Questionnaire prompted participants to indicate their experience. This served two purposes: verify the inclusion criterion and obtain descriptive statistics. One measure of experience was the number of task analyses conducted. Thus, participants answered the question of how many task analyses they conducted in the past (1) year. The average number of task analyses was 12.8 (*SD*=17.7), ranging from 2 to 50. Data suggest that there were two groups of participants. One group consists of six participants who indicated that they conducted between two and five task analyses in the past one year. The second group consisted of 2 participants who indicated that they conducted between 30 and 50 task analyses, one participant annotating that this number pertained to using task analysis to evaluate employee performance.

Furthermore, participants indicated how many task analyses they conducted in their professional experience. Two participants noted that they had conducted fewer than 5 task analyses, one participant conducted between 6 and 12 task analyses, and the remaining 5 participants indicated that they conducted more than 50 task analyses in their professional life. This illustrates two points: first, participants fulfilled the experience requirements and, second, that professionals can differ greatly in the number of task analyses they conduct in their professional life and on a yearly basis.

What Tasks Do Professionals Analyze?

Given that task analysis can be used in a variety of settings, it was also of interest to obtain a sense of the tasks that professionals analyze. Participants indicated a wide range of the kinds of tasks they analyzed in the past and differed in how specific they were about those tasks. The kind of tasks participants had analyzed included military, industrial, office, factory, work, and service industry tasks. More specific descriptions included software installation, authentication, window management, and graph construction.

Participants also listed cognitive tasks (decision-making, critical thinking), complex performance (equipment diagnostics, equipment operation), aircraft maintenance as well as repair and vehicle manufacturing. Tasks also included TSA Checkpoint screening, checked bag screening, Aircraft mechanic tasks (various), flight attendant job tasks while in flight & multiple segments, general baggage handling tasks (ramp & bag room), reservationists tasks, cargo personnel tasks. Participants also reportedly analyzed how a person works at a desk, how a person performs various household activities (e.g., cooking or cleaning), how a person performs specific computer tasks, pops popcorn, uses a telephone, or checks in at a hotel. This shows that participants' tasks were very diverse and spanned from household work to repairing an airplane.

Why do Professionals Conduct Task Analysis? Purposes and Goals

A task analysis is undertaken for a particular purpose, that is, with a guiding framework in mind, and has a specific goal, that is measurable. The purpose of the analysis is an important variable that influences the task analysis (Kirwan & Ainsworth, 1992), and thus it is important to understand why professionals in this sample conduct a task analysis. The Demographics and Experience Questionnaire provided a list of purposes for conducting a task analysis, asking participants to indicate for which purposes and goals they conducted task analysis and rank these in the frequency used.

Figure 5.1 shows participants' rankings of the task analysis purposes. Participants used task analysis for a range of purposes. Six of eight participants conduct task analysis for the purpose of task design and for the design of equipment and products. However, participants also conduct task analysis for the purpose of training individuals and less often also for environmental design.

Two purposes not captured by the questionnaire categories were the identification of barriers to person-environment fit and selection of jobs for individuals with disabilities. This is interesting as it shows that task analysis is used both to select a "new individual" for an "existing job" as well as find a "new job" for an "existing employee" who has a fixed set of capabilities.

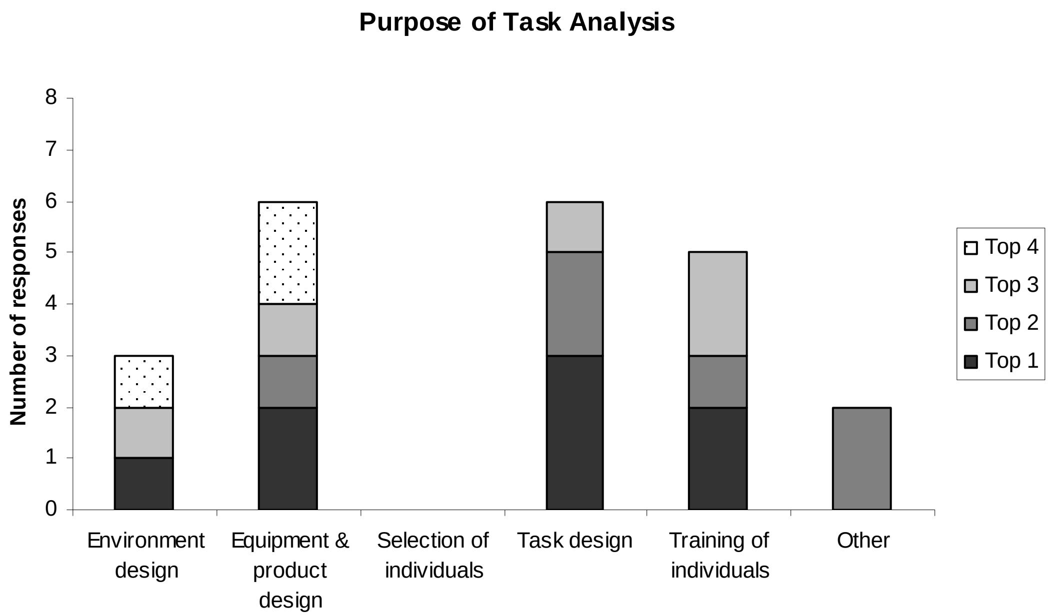

Figure 5.1: Participants' top ratings of their purposes for conducting task analysis (*N*=8).

Participants also indicated the top rankings of the main goal for conducting a task analysis. As illustrated in Figure 5.2, participants clearly indicated that the first and second most frequent main goal was to enhance performance and increase safety. Increasing comfort and user satisfactory were also a goal, but this was less frequently the case. One main goal not captured by these categories was to find an assistive technology fit, whereby the focus is the person and finding something that fits the person. From the data we learn that task analysts' goals and purposes are captured by the categories; however, these categories are not all-inclusive. Furthermore, although participants conducted task analysis for a variety of purposes, their primary goals are to enhance performance and increase safety.

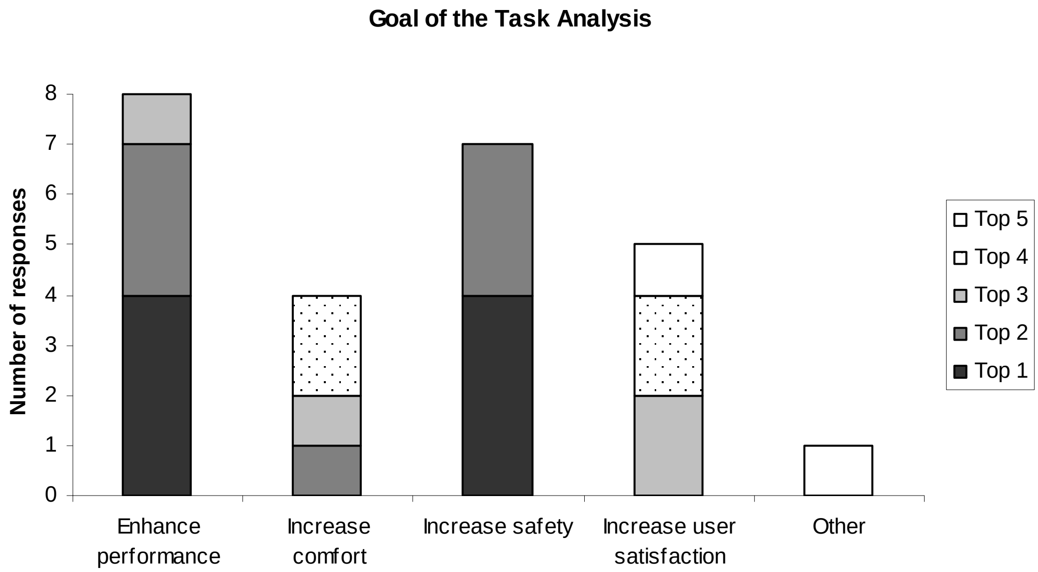

Figure 5.2: Participants' top ratings of their goals for conducting task analysis (*N*=8).

What Do Professionals Emphasize in their Task Analysis?

There are many aspects of a task that participants could address in their task analysis. To obtain a sense of what this study's professionals focused on, they were asked to rate a list of emphasis items on a scale from one (no emphasis) to five (lot of emphasis) in terms of what participants generally emphasized in their task analysis. As can be in seen in Table 5.1, many of the participants emphasized actions in their task analysis. Furthermore, many participants placed a lot of emphasis on describing tasks as they are completed (descriptive); however, some participants also emphasized how those actions should be done (normative). Tasks aspects that were least emphasized over all participants were affective and sensory/perceptual.

Table 5.1

Task Analysis Emphasis in Order of Frequency (Mdn)

Rating	*Mdn*	1 (no emphasis)	2	3	4	5 (lot of emphasis)
Actions	5				3	5
Descriptive	5		1	1		6
Goals and subgoals	4.5	2			2	4
Motor	4	3			2	3
Normative	3.5		1	3	1	3
Cognition	3.5	1	1	2	3	1
Sensory/perceptual	2.5	2	2	1	2	1
Affect	2	4		1	3	

Note. The number of participants was eight.

Summary of Experience

All participants fulfilled the minimum required experience with conducting task analysis. Participants varied in that some participants conducted only a few task analyses per year (and in their career), whereas others conducted a large number of task analyses (per year and in their career). Tasks that have been analyzed varied across industries and covered a range from activities of daily living to maintaining an aircraft. Participants used task analysis to design equipment, tasks, and environments, fitting the person to the job but also the job to the person. The primary goals of conducting task analyses were performance and safety. This variety in tasks and analytical emphasis is important to keep in mind when understanding similarities and differences in the characteristics of participants' task analysis products and process.

Task Analysis Products

Task analysis products were coded on a number of dimensions to determine the characteristics of professionals' task analyses as well as create a basis on which to calculate inter-analyst agreement. Two coders coded all task analyses and disagreements were resolved through discussion. Table 5.2 shows the coding scheme (see Appendix C.1 for details), which is based on hallmark features described in previous research (e.g., Patrick et al., 2000). Overall coder agreement was 84% (see Appendix C.2. for reliabilities). The goal was to obtain a general sense of professionals' task analysis products. The expectation was that professionals' task analyses would have a depth of at least two levels, include main level subgoals, and be versatile.

Table 5.2

Coding Scheme for Task Analysis Products

Criterion	Questions
Hierarchy dimensions	- What is the breadth of the task analysis? - What is the depth of the task analysis?
Subgoals	- What subgoals of the task are included? - What level of subgoals do participants focus on?
Versatility	- Is the task analysis general or specific? (Do participants consider variations of the task, e.g., different input material or equipment?)

Hierarchy Dimensions

A hierarchy can be described in terms of its breadth and depth. To obtain a measure of the hierarchy, each task analysis received two numbers. One number indicated the breadth of the task analysis, that is, the number of subgoals on the first level of task analysis. The second number indicated the maximum depth of the task analysis as a whole. Two coders determined the breadth of the analysis at the highest task level and the depth of the analysis at its deepest level.

Over all tasks and participants, tasks were on average 6.1 subgoals wide (SD=4.23), ranging from 2 to 21 subgoals. Because of a small number of participants, a non-parametric Friedman test was conducted to determine differences in breadth between tasks. Tasks significantly differed in their breadths overall (χ^2= 11.67, df=5, p=.04); however, follow-up multiple comparisons using the Wilcoxon test and a Bonferroni-adjusted alpha-level did not indicate significant differences between all pairs (see Appendix C.3). No difference in breadth was observed when comparing the familiar tasks (*making breakfast, arranging meeting)* and unfamiliar tasks (*making Vetkoek, sharing pictures),* (p=.72).

The average breadth of professionals' task analyses was within the suggested boundaries of three to eight subgoals. However, a closer look at the data showed that professionals in this study created task analysis that were beyond the suggested boundaries of three to eight elements (see Figure 5.3). The broadest and flattest analyses were created for *making sandwich*, with two participants creating the broadest task analyses of 19 and 21 elements. This illustrates professionals' inter-individual variability and that they do not necessarily adhere to the suggested breadth in literature.

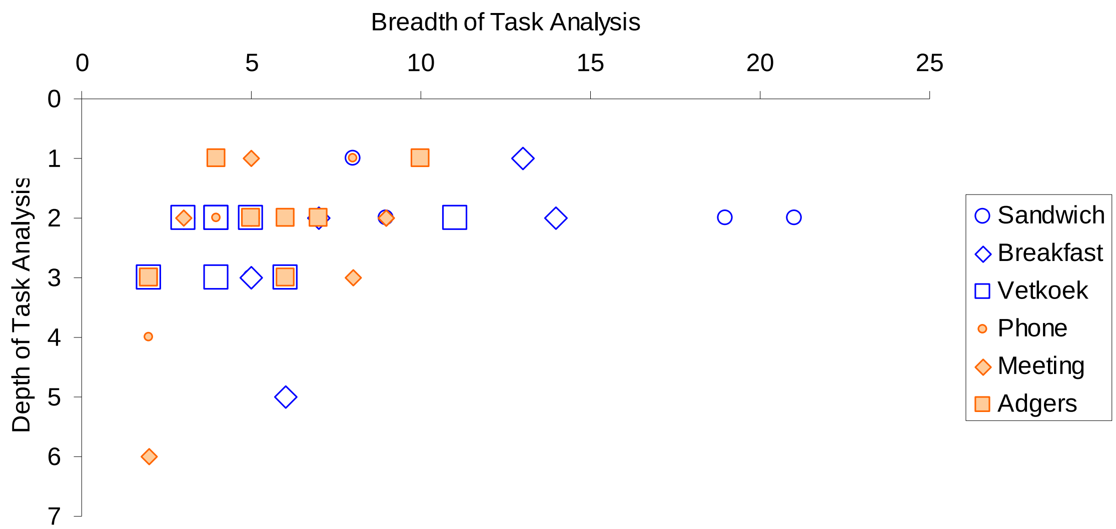

Figure 5.3: Breadth and depth of task analysis (TA) for all six tasks.

The second dimension of a hierarchy is its depth. Professionals' task analyses were on average 2.3 levels deep (*SD*=.95), and ranged in depth from 1 to 6 levels at its maximum. A Friedman test showed that task analyses did not differ significantly in depth between tasks comparing all tasks (*p*=.88) and comparing the familiar and unfamiliar tasks number 2, 3, 5, and 6 (*p*=.94). This indicates that professionals were able to create deep analyses (more than one level) for specific tasks such as *making sandwich* or *making phone call*, and even when no specific details were available (unfamiliar tasks). However, as illustrated in Figure 5.3, some professionals created task analyses that were only one level deep (see Appendix C.4 for breadth and depth means and standard deviations for each task)

Subgoals

Of interest was what subgoals professionals included and excluded from task analysis. Subgoals were defined as verb-noun pairs, identified, and coded against the pre-defined master task analyses (see Appendix A.2).

Making sandwich. For the cooking related tasks, participants mostly focused on following the recipe. For the task of *making sandwich* (see Table 5.3), people concentrated on describing the procedure, with rarely mentioning to determine what to make (part of get recipe) or serving the sandwich. However, five of eight participants included enjoy the sandwich. A notable number of verb-noun pairs (13%) were devoted to wrapping up, that is, cleaning. There was a noticeable symmetry, for example, open jar was followed by close jar, open the fridge was followed by a close the fridge, and open the sandwich was followed by a close the sandwich. Cleaning can be viewed symmetrical to the sandwich making activity.

Table 5.3

Subgoals Related to Making Sandwich

Subgoals	Count	Percent Subgoals Main Level	Percent Subgoals Lower levels
1. Get recipe	0	0%	
- Lower level subgoals	5		3%
2. Follow recipe	0	0%	
- Lower level subgoals	141		80%
3. Serve	2	1%	
- Lower level subgoals	1		1%
4. Enjoy	5	3%	
- Lower level subgoals	0		0%
5. Wrap-up	0	0%	
- Lower level subgoals	22		13%
Sum	176	4%	97%
Extra	2		

Note. Counts are based on eight task analyses.

Making breakfast. For the task of *making breakfast* (see Table 5.4), participants also focused mostly on the actual preparing of food, and rarely mentioned preparation of a beverage. Some participants went into "determining what to make", which is not surprising, given the wider variety of breakfast foods. Again, participants noted wrap-up activities such as cleaning the dishes. Two participants went as far as turning off the lights, which were coded as extra.

Table 5.4

Subgoals Related to Making Breakfast

Subgoals	Count	Percent Subgoals Main Level	Percent Subgoals Lower levels
1. Determine what to make	3	1%	
- Lower level subgoals	28		12%
2. Prepare food	1	0%	
- Lower level subgoals	155		64%
3. Prepare beverage	0	0%	
- Lower level subgoals	2		1%
4. Serve	1	0%	
- Lower level subgoals	25		10%
5. Enjoy dish	4	2%	
- Lower level subgoals	4		2%
6. Wrap-up	0	0%	
- Lower level subgoals	18		7%
Sum	241	3%	97%
Extra	5		

Note. Counts are based on eight task analyses.

Making Vetkoek. For the task of *making Vetkoek*, participants spent much of their analytical focus on obtaining a recipe and figuring out what Vetkoek is, how to make it, where it comes from, whether they might have the ingredients, and if they had the equipment and knew the techniques involved in making the dish. This can be interpreted as participants spending a large proportion of their analytical interest on learning what Vetkoek is (see Table 5.5), which means their role as a task performer and their role as a task analyst blur. Again, task analyses included wrap-up activities, which suggests that wrapping up is part of the general cooking task structure as perceived by this study's participants.

Table 5.5

Subgoals Related to Making Vetkoek

Subgoals	Count	Percent Subgoals Main Level	Percent Subgoals Lower levels
1. Get recipe	2	1%	
- Lower level subgoals	55		38%
2. Follow recipe	4	3%	
- Lower level subgoals	59		40%
3. Serve	3	2%	
- Lower level subgoals	8		5%
4. Enjoy	2	1%	
- Lower level subgoals	0		0%
5. Wrap-up	0	0%	
- Lower level subgoals	13		9%
Sum	146	7%	93%
Extra	4		

Note. Counts are based on eight task analyses.

Making phone call. Here, participants focused on subgoals related to determining the receiver (38% of subgoals) and connecting (40%). Little emphasis was placed on obtaining a phone and not as many wrap up activities were involved as compared to the cooking domain. Table 5.6 shows the frequencies of phone-related subgoals.

Table 5.6

Subgoals Related to Making Phone Call

Goals	Count	Percent Subgoals Main Level	Percent Subgoals Lower levels
1. Determine receiver	0	0%	
- Lower level subgoals	25		38%
2. Obtain phone	0	0%	
- Lower level subgoals	1		2%
3. Connect	0	0%	
- Lower level subgoals	26		40%
4. Communicate	2	3%	
- Lower level subgoals	8		12%
5. End call	1	2%	
- Lower level subgoals	2		3%
Sum	65	5%	95%
Extra	4		

Note. Counts are based on eight task analyses.

Arranging meeting. The task analysis focus of *arranging meeting* included determining date and time, attendees, location, and preparing for the meeting (see Table 5.7). Little emphasis was given to determining the reason for the meeting, confirming the details, and the meeting itself. One could argue that the task of arranging a meeting does not include the meeting itself and thus this finding should not be surprising. However, one may also argue that making a phone call does not include the conversation, yet, participants did include this in their task analyses. This shows that participants framed the task of making a phone call more broadly than the task of arranging a meeting. Nobody included any items related to ending the meeting.

Table 5.7

Subgoals Related to Arranging Meeting

Subgoals	Count	Percent Subgoals Main Level	Percent Subgoals Lower levels
1. Determine date & time	0	0%	
- Lower level subgoals	25		28%
2. Determine attendees	1	1%	
- Lower level subgoals	14		16%
3. Determine location	2	2%	
- Lower level subgoals	13		15%
4. Determine reason for meeting	1	1%	
- Lower level subgoals	6		7%
5. Confirm meeting details	0	0%	
- Lower level subgoals	6		7%
6. Prepare for meeting	1	1%	
- Lower level subgoals	15		17%
7. Meet	1	1%	
- Lower level subgoals	4		4%
8. End meeting	0	0%	
- Lower level subgoals	0		0%
Sum	89	6%	94%
Extra	4		

Note. Counts are based on eight task analyses.

Sharing pictures. For the task of *sharing pictures* using Adgers, participants mainly analyzed loaning the picture, followed by connecting using Adgers, obtaining the picture, and determining which picture to be shared, with only few mentioning of determining receiver information (see Table 5.8). As with the task of *arranging meeting*, the end of sharing pictures as a closing symmetry is not included within the task boundaries. Participants included in their task analyses efforts to obtain a copy of the software, install it, use a tutorial, and explore the software to become familiar with it, thus including tasks in the task analysis that they would normally do as a performer of the task.

Table 5.8

Subgoals Related to Sharing Pictures

Subgoals	Count	Percent Subgoals Main Level	Percent Subgoals Lower levels
1. Obtain picture	0	0%	
- Lower level subgoals	8		16%
2. Determine picture to be shared	1	2%	
- Lower level subgoals	7		14%
3. Determine receiver information	0	0%	
- Lower level subgoals	4		8%
4. Share picture/loan picture	2	4%	
- Lower level subgoals	18		35%
5. Connect using Adgers	1	2%	
- Lower level subgoals	10		20%
6. End sharing	0	0%	
- Lower level subgoals	0		0%
Sum	51	8%	92%
Extra	24		

Note. Counts are based on eight task analyses.

Similar to the unfamiliar task of Vetkoek, participants spent much of their analytical focus on learning about Adgers, and these comments were coded as extra. Only one participant pondered about the boundaries and decided *not* to include learning: "*I'm trying to decide where I would start since I don't have a clue what Adgers is. So I'm trying to decide if I would include something like learn what Adgers is, is part of the task analysis. Presumably if I'm doing a task analysis though, I wouldn't, normally I wouldn't include something like that, it's part of the task of actually sharing the pictures.*" This suggests that professionals who are conducting task analysis can use their inexperience with a task as a guide but also have to be careful not to confuse their roles of task performer and task analyst.

Level of analysis. An overview of all tasks by domain is presented in Table 5.9 and provides the basis for answering the question of what level of subgoals professionals focus on. It is noteworthy that overall only about 5% of all identified subgoals were matched to a high-level goal of the master task analyses. Instead, participants were specific in their analysis with 90% of subgoals focus on lower level subgoals, and depending on the task also including extra subgoals. Tasks of the cooking domain included wrap-up activities such as cleaning and storing away times. Wrap-up activities were mentioned for *making phone call* (end call), but not for the other communication tasks.

Table 5.9

Number of Subgoals Identified for All Tasks

	Main Level Subgoals		Lower Level Subgoals		Extra Subgoals		Sum
	Count	%	Count	%	Count	%	Count
Cooking							
Sandwich	7	3.9	169	94.9	2	1.1	178
Breakfast	9	3.7	232	94.3	5	2.0	246
Vetkoek	11	7.3	135	90.0	4	2.7	150
Communication							
Phone	3	4.3	62	89.9	4	5.8	69
Meeting	6	6.4	83	88.3	5	5.3	94
Adgers	4	5.3	47	62.7	24	32.0	75
Sum	40	4.9	728	89.7	44	5.4	812

Note. The basis for these verb-noun pairs are 48 task analyses.

Two participants noted the similarities between tasks within a domain. One participant (jokingly) said *"Make Vetkoek.. If I'm gonna anything, locate, well, choose ... choose the recipe ... can I just copy the last one that I did?"*, and a different participant noticed *"Well, initially, arranging a meeting seems very much similar to making a phone call (laughs), and so I'll start in a similar fashion"*. Both of these participants were on the broad and general approach spectrum described earlier. This is important because it suggests that participants perceived an underlying task structure common to the tasks.

Versatility of the Task Analysis

A main advantage of functional task analyses is that it is generalizable across different solutions (Annett, 2004). To assess to what extent participants' task analyses were versatile, task analyses were coded as to whether they were general or specific to a technology, ingredients, or procedure. Data analyses showed that only 56% of participants' task analyses were general (see Table 5.10). However, differences between participants existed too. One participant created specific task analyses for all tasks, another created general task analyses for all task, and the remaining participants were distributed between the two extremes.

Table 5.10

Versatility of All Task Analyses

Tasks	Specific	General
Cooking		
Sandwich	3	5
Breakfast	4	4
Vetkoek	4	4
Communication		
Phone	4	4
Meeting	4	4
Adgers	2	6
	21	27

Note. Data are from eight task analyses per task, and a total of 48.

One may ask how it is possible to create a specific task analysis especially for an unfamiliar task such as Vetkoek and Adgers, for which no procedural details are available. The task analyses themselves along with the think-aloud protocols provide clues as to underlying reasons. Think-aloud data suggest that participants constrained their problem space very tightly. For example, one participant constrained the task analysis of making Vetkoek so that it only included finding a recipe for Vetkoek in a cookbook. When analyzing Adgers, some participants had existing software such as Facebook in mind and were guided by this knowledge and experience.

However, not all participants expressed having Facebook in mind or produced a specific task analysis with Facebook in mind. Another explanation of why participants created specific task analyses is that participants generally differ in the solution space to which their task analysis is meant to apply, that is, the purpose of the task analysis. To illustrate, participants who use task analysis to evaluate the capabilities of a specific person to perform a certain job do work with clearly defined parameters. The person has defined parameters in terms of capabilities and limitations and so does the environment and objects (e.g., phones) in that environment. Thus, the task analysis is specific to each individual that is being assessed. On the other hand, one participant started out with a particular scenario and then tested how the task analysis held when expanding the assumptions to different scenarios, thus creating a general task analysis needed for system or training design.

Summary Task Analysis Products

No data exist to date that captured and described the characteristics of experienced task analysts for the tasks described. Data analysis focused on the following task analysis product characteristics: Hierarchy dimensions, subgoals, and versatility. The task analysis breadth was on average 6.1 subgoals wide with some task analyses as small as 2 and as broad as 21 subgoals. Task analyses had an average depth of 2.3 levels at its deepest; however, some task analyses were only 1 level deep. Compared to the master task analyses created for this study, professionals did mention main level subgoals but focused on identifying lower level ones. Participants included subgoals related to learning about unfamiliar tasks. Wrapping-up activities were included for all tasks in the cooking domain but only for *making phone call* in the communication domain. Only 56% of professionals' task analyses were versatile, that is, considered general and not specific to a person, technology, or procedure. Possible reasons included participants purposely constraining their problem space, modeling a particular technology, and the purpose of the task analysis focusing on a 1-person-technology-environment.

Task Analysis Process

The think-aloud protocols provided the basis for analyzing the task analysis process as an account of what was happening as participants conducted the task analysis. Two approaches were derived from literature to describe how participants approached the task analysis: (1) Do participants determine first the breadth of the analysis or analyze subgoals in depth first before determining the next subgoal?, and (2) what questions do participants ask? Because assumptions can be viewed as the flip-side of questions, these were analyzed as well. See Appendix C.5 for the coding scheme of the task analysis process and Appendix C.2 for reliability values. Overall agreement was 86%.

Breadth or Depth First

Task analyses were coded as to whether the participant approached it breadth-first or depth-first, based on the task analysis that participants created as well as based on information from the think-aloud protocol for that task. A task was coded as breadth-first also if there was no hierarchy, that is, for those two instances in which participants created a task analysis that only had a depth of one.

As Table 5.11 illustrates, about half (44%) of task analyses were created by a breadth-first approach and 56% were done depth-first. Cooking tasks were more likely to be conducted depth-first and communication tasks were more likely to be conducted breadth-first (χ^2= 5.76, *df*=1, *p*<.01). It is also worthwhile pointing out that one participant switched from breadth-first to a depth-first approach when finished the communication tasks and switching to *making sandwich*. This participant noted this while analyzing breakfast *"I just realized that I rushed right into the making the peanut butter jelly sandwich without clarifying the assumptions that I had there, which was that the sandwich was for me."*

Table 5.11

Number of Participants Who Chose a Breadth-First or Depth-First Approach

	Sandwich	Breakfast	Vetkoek	Phone	Meeting	Adgers	Sum
Breadth-first	1	2	2	5	7	4	21
Depth-first	7	6	6	3	1	4	27

Note. Total number of participants per task was eight.

One participant's comments sheds light onto the benefits of a breadth-first approach: "So what I try to do first, I would start with the breadth-first analysis, 'cause I want, what I want to understand is, do I understand the end problem? You know, are there any big gaps in my knowledge about where the user is going to start and where the user is gonna end up?" … Besides determining the boundaries of the task, this participant also noted that a breadth-first approach prevents the team from wasting time outlining details of a branch that may be cut out of the project at a later point. Lastly, having specific details may be counterproductive to creating a shared understanding of the problem first because software developers will start coding too early in the process.

Professionals' Questions During a Task Analysis

The think-aloud protocols were coded for whether participants mentioned the questions "who, what, where, when, why, and how" during a task analysis. A segment was defined as an idea unit, containing a question that furthered the task analysis (i.e., not including questions to the experimenter). The think-aloud protocols were conservatively coded, that is, questions that were phrased as statements were not included. One coder selected the segments and two coders coded them. The coding scheme included an "other" category for questions other than the ones previously mentioned.

All participants asked questions at some point during their task analysis; however, participants varied greatly in the number of questions they asked while performing a task analysis, from none to 16 for one task and between 1 and 51 overall across all six tasks. Participants asked a total of 130 or on average 29 questions per task (*SD*=5). The distribution of questions was not equal. As illustrated in Figure 5.4, most questions pertained to *what* (43%), followed by questions about *how* (16%). The remaining four questions accounted only for 16% of the remaining questions, whereas 25% of the questions were not captured by the 6 questions in the coding scheme.

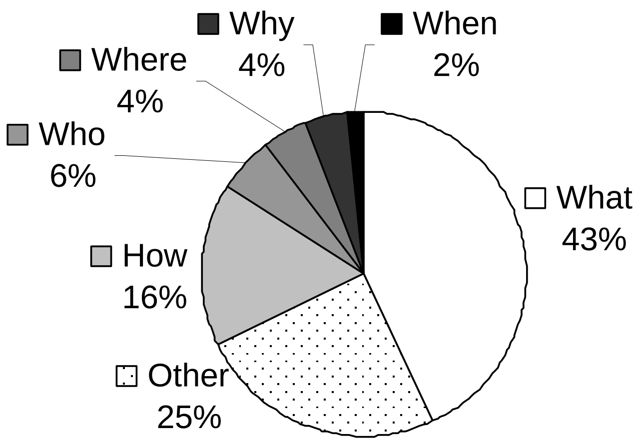

Figure 5.4: Distribution of segments related to different kinds of questions.

What? Participants asked mostly *what* questions (43% of segments), and common themes emerged from these questions. One category of questions can be described as trying to understand the task space, for example “What is it?” or “What type of main dish?, especially with the unfamiliar tasks of Vetkoek and Adgers (e.g., What are the system requirements?, What are the capabilities?). A related category of questions that define the task space include questions that specify instances (e.g., What type of jelly? What type of phone? What type of materials? What would you use?). These questions can viewed as identifying the major class of objects involved in the task and understanding what particular instances of the objects are to be present. Interestingly, some participants asked these narrowing questions at the onset of the analysis and chose a particular instance before proceeding, whereas other participants asked these questions as they went through the analysis and incorporated these questions in their analysis, or just chose an instant at that specific decision point.

A third category of *what* questions relate to the procedure of the task, such as "What is next?", "What is the process?", "What are the steps?", "What is the first step?" and "What do I do?". A fourth category of *what* questions relate to understanding and specifying requirements (e.g., "What would I need? What utensils do I need?"). A fifth category of common questions that task analysts asked included checking specific aspects of a task: "What will I need to know?", "What will I need to be able to do?", "What would the knowledge behavior be?", "What behavior would I use?", and "What kind of motor skills are involved?". Participants also occasionally asked "what if" questions to understand alternative paths, and kept asking "what else" to search the task space for potentially undiscovered task elements.

Interestingly, questions were also phrased such that they fell in a different category. For example, a *who* question was phrased as "what's the audience" and a "how long" question was phrased as "what takes the longest?". This suggests that participants may rephrase open ended questions (with the goal to find information for how long each one takes) into a more specific question that guide them to the next step, in this case, to start with the item that takes the longest.

How? Questions that contained *how* were the second most frequently mentioned question category (16% of the segments). Questions mostly related to "how to" followed by a verb, for instance, how to share, how to have, how to use, how to dial, how to open, or how to choose. However, there were also questions related to number (how many), time (how far back), assessment of ability (e.g., how able is he to maneuver) and even looking for answers (e.g., how can he cue himself?)

When, Where, Who, and Why? Only 16% of segments fell into the four remaining question categories. *Where* questions could refer to a location of an object (e.g., "Where is the peanut butter?") or to a starting point of the task analysis ("Where do I start?"). *Who* questions were focused on defining an audience and included a bigger picture question such as "who do you want to share the pictures with?" to a more fine grained follow-up question "who in the family?". One participant contributed to seven of the nine *why* questions. This participants questioned the assumption of the main goal, that is "Why are we sharing pictures?" or "Why are we using Adgers" at the beginning of the task analysis.

Other questions. The six questions captured a majority of the questions participants asked while conducting the task analyses (i.e., 75%). However, 25% of the segments included questions that did not fall clearly in one the 6 question categories. Participants asked questions that were more focused and required a yes/no answer, for example when assessing behavior (e.g., "is he able to do x?" or "is he doing y?"), determining timing ("are there things that are going to be done in parallel?"), and use questions as a check by asking "is there.." (e.g., "anything I need to know?"). Furthermore, participants are searching for the right word ("stove .. use it? Employ it?") or ask "Do I…" (e.g., "Do I create the agenda before?" or "Do we have everything necessary?").

Professionals' Assumptions During a Task Analysis

The think-aloud protocols were inspected again for whether participants mentioned assumptions during a task analysis. Using a conservative approach, a segment was defined as an idea unit containing the words "assume", "assuming", or "assumption".

Overall, participants made 69 assumptions and varied greatly in the number of assumptions they made. Two participants did not state any assumptions while thinking aloud, and 2 other participants accounted for 80% of the assumptions explicitly stated.

Some assumptions were clearly related to one of the six questions posited earlier (e.g., assumption about *who* is the user). However, because the same assumption could be related to different outgoing questions it was difficult to establish reliability. Nevertheless, some subcategories of assumptions emerged: assumptions about the user (e.g., who am I making this for), experience (e.g., I have used/never used this before), ability (assume that he can/cannot reach), location and prerequisites (e.g., I assume I have a kitchen and the ingredients are already there so I don't have to go out and buy them), particular make up (e.g., assume a jar – as opposed to other peanut butter containers). Furthermore, one participant actively rejected an assumption which influenced what tasks he subsequently analyzed, and also pointed out that there are assumptions embedded within assumptions by saying "So end user.. is me. And there's assumptions embedded in what me means".

Placing Participants in a Task Analysis Process Space

A breadth-first approach first considers the main variables or high-level subgoals of a task and can be viewed as understanding the problem space. Thus, the question was whether a breadth-first approach was associated with a larger number of questions and assumptions. Figure 5.5 shows for each participant, how many task analyses were considered breadth-first (out of six) and how this maps onto the sum of questions and assumptions (the flip side of questions). Keeping in mind that the data for questions and assumptions were derived from think-aloud protocols, a trend was observed such that participants who tended to ask more questions also tended to use more breadth-first approaches. However, this positive relationship (r=.43) was not significant.

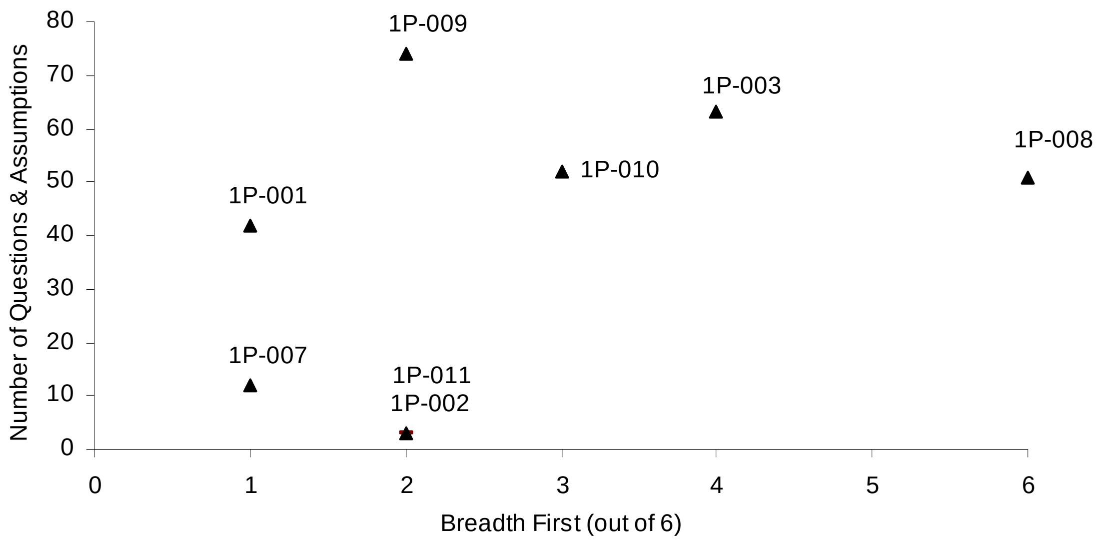

Figure 5.5: Mapping the number of breadth-first approaches to numbers of questions and assumptions.

Drawing from the think-aloud data, participants' general approach can be described as follows: Three participants (#2, #7, #11) uttered few words (M=344, M=359, M=359) while thinking aloud, and few of these words were questions and assumptions. These participants mainly outlined the steps they would go through as they would perform the tasks. These participants tended to use depth-first approaches. A second group of participants, participants #1, #8, and #10, generally uttered more words per task (M=644, M=645, M=830), asked more questions, and stated more assumptions. Two of these participants outlined a detailed scenario, picking specific instances of people, environment, and so forth. Lastly, participants #3 and #9 can be described as uttering many words (M=1016, M=1591), asking many questions, and stating many assumptions. One of these participants started out by questioning the main assumption of the task.

Summary Task Analysis Process

The process of task analysis was examined in terms of breadth or depth-first, questions asked, and assumptions made before participants' overall approach was briefly described. About half of the task analyses (56%) were conducted breadth-first, and a practical reason emerged for the benefits for this approach, namely to ensure that the problem is understood before solved. Participants used questions to define their problem space and used them as a guide through the analysis. Participants also stated and used assumptions to guide their analysis and referred back to them as they proceeded through the analysis. Questions mostly centered around the *what* and *how*, and included many closed-ended questions. One participant accounted for most of the *why* questions, posing these at the onset of the analysis. Some participants just retrieved information from memory, whereas others created scenarios and defined their problem space.

CHAPTER 6: STUDY 1 - DISCUSSION

The goal of study 1 was to capture characteristics about the products and processes of experienced task analysts. Collecting information about skill expression is the first in three steps of studying expertise (Ericsson & Smith, 1991), and provides information about goals of skill development and some basis against which to adjust current performance. Because experts in task analysis are unknown, the study focused on professionals with at least two years of experience performing task analysis. The sample size of this study was small because of the exploratory nature of this study. However, questions and hypotheses generated from this study can be used to guide future studies that can then be tested with a larger sample size.

Three research questions were related to characteristics of professionals' task analysis products: 1) What are the hierarchy dimensions in terms of breadth and depth, 2) what subgoals do professionals identify and focus on, and 3) are professionals' task analysis products versatile (general)? Three questions related to the characteristics of the task analysis process were: 1) Do participants employ a breadth-first or depth-first approach, 2) what questions do professionals ask?, and 3) What assumptions do professionals make?

Characterizing Professionals' Task Analysis Products

Hierarchy Dimensions

The average breadth of participants' task analyses was six subgoals wide. The average as well as the majority of the task analyses (60%) fell within the suggested range of three to eight subgoals. However, participants also produced task analyses that were much broader (23% of task analyses were up to 21 subgoals wide), whereas 17% of task analyses were very narrow (2 subgoals wide). Breadth did vary between tasks, but not as a function of familiarity. This illustrates that although professionals' task analyses were mostly within the suggested bread boundaries, professionals do not necessarily adhere to the suggested breadth in literature. Given the inter- and intra-individual variability of breadth, future research could address which factors underlie and influence the breadth width on the first level.

As for the task analysis depth, participants created task analyses that had an average depth of two to three levels irrespective of task, ranging from one to six levels. Participants created task analyses deeper than one level for unfamiliar tasks, that is, when specific details are unknown. These data provide ballpark numbers and show that it is possible to create a hierarchy for specific tasks such as *making phone call* and *making sandwich.* Interestingly, some professionals created a task analysis of only one level deep, and it is not clear whether this illustrates superior performance. The stability of depth over six tasks suggests that participants have a certain depth in mind for their initial draft of a task analysis created within 15 minutes.

No clear rules emerged as to why some participants analyzed a task to a greater depth than others. However, clues as to the importance of the purpose of the analysis emerged. Defining the purpose of conducting the task analysis in the first place is mentioned throughout literature (e.g., Kirwan & Ainsworth, 1992); however, it is often not made explicit *how* it informs the analysis, that is, how the purpose of the analysis influences the choice of depth or the choice of which elements to analyze further. Such information could be sought in a separate study.

A hierarchical representation also means that the task analysis has at least two levels, irrespective of the visual rendering of these levels. A hierarchical representation also means that a subgoal is being redescribed into at least two subgoals or not at all. These aspects of redescription were not evaluated and still need to be addressed in future research. Furthermore, it is unknown if and how the final depth of a task analysis may change, another topic that future research may investigate. Lastly, future research may address the relationship between breadth and depth, that is, whether there is an optimal breadth-depth ratio and whether breadth determines depth and vice versa.

Subgoals

Data analyses showed that professionals focused on identifying lower level subgoals (90% of subgoals) with 5% of the subgoals being the ones identified on the highest level in the master task analyses and another 5% extra (i.e., outside of the boundaries of the master task analyses). These patterns are beneficial to understand novice performance given the same task constraints. However, a future study could address the question of how representative this initial draft, created by professionals within 15 minutes, is of the final product.

Participants differed in how detailed they analyzed portions of the task, with some participants outlining in detail what is involved in going to the grocery store and obtain food items, whereas other participants just stated the higher-level elements of obtaining ingredients. Participants included subgoals such as learning about unfamiliar tasks; however, one participant reflected on whether this would be part of the task analysis and decided to exclude it. Including learning about an unfamiliar task into the task analysis illustrates that participants let their role as a task performer inform their task analysis. It is not clear if this is beneficial and a resource for the tak analyst, or whether this role confusion is a potential pitfall that should be addressed during training, especially given that task analysts often draft a task analysis before meeting the subject matter expert.

Participants also included symmetrical subgoals for tasks in the cooking domain and for *making phone call* in the communication domain. Jars, drawers, and fridges that were opened were also closed. It is unclear whether no such symmetries exist for the *arranging meeting* and *sharing pictures* or participants did not focus on them. If tasks do indeed contain an internal task symmetry, this could be an important cue for the task analyst to check if the analysis is complete. This might also be a useful guide for novice analysts to help them develop complete analyses.

Versatility

Functional task analyses in particular should be general. However, data with respect to task analysis versatility showed that even experienced task analysts are overly specific. Not all participants created general task analyses and not all created general task analyses for all tasks. Professionals' task analyses were not as versatile as expected, with only 56% of professionals' task analyses considered general and not specific to a person, technology, or procedure.

Think-aloud data brought about possible reasons, suggesting that versatility may be influenced by how tightly the participants constrained the task space, whether they had a very specific technology in mind, and the purpose of the task analysis. A future study could investigate how task analysis versatility differs as a function of number of assumptions and task constraints provided. These findings are also important for assessing novice performance. Novices may also create specific task analyses but not necessarily because they constrain their task but because they ignore the task variations.

Characteristics of Task Analysis Process

Literature has suggested a task analysis process on a general level that included gathering data, analyzing data, and presenting data (Redish & Wixon, 2003). This study elaborated these phases, focusing on describing the process in terms of a breadth-first or depth-first approach, the questions professionals asked, and the assumptions they made.

Breadth or Depth First

The debate about whether a task analyst chooses to analyze the breadth or the depth of a task first (Jonassen et al., 1999) was reflected in the data as 56% of the task analyses were coded as breadth-first. One participants' rationale was that a breadth-first approach prevented solving the problem before it was understood. Cooking tasks were more likely analyzed depth-first and communication tasks breadth-first. Current coding criteria were very stringent and did not account for participants employing a combination of approaches, a direction that future analyses could explore along with how a breadth-first or depth-first approach is associated with the type of task or task product characteristics.

Questions

Participants used questions to guide their process, with the majority of questions being *what* questions (45%), followed by *how* questions (16%). Categories of *what* emerged and indicated that participants used what questions trying to understand the task space and identify its objects (*What is it? What kind of jelly?*), elicit information about the procedure (*What is the next step?*), and specify the requirements (*What would I* *need?*). Questions also related to understanding specific task aspects, such as knowledge, skills, behavior. For example, one participant repeatedly self-cued with specific questions such as “what is the motor skill involved” or “what knowledge is associated with it?” or kept searching the problem space by asking “what else”? Questions were open ended to understand the task space and the variables involved but also included closed ended questions designed to narrow down the task space either at the beginning of the task analysis or as the analyses progressed. This suggests that the same or similar questions can be used to accomplish different goals in this phase of the task analysis.

Assumptions

Kieras (2004) noted the importance of stating assumption in a task analysis. Professionals in this study differed to what degree they mentioned assumptions and defined the scenario for which their task analysis was valid. Task analysts whose occupation was to understand how one particular person performs a task might focus on the assessment because the medical chart of a person already contains the underlying assumptions. However, this analyst might be interested in obtaining a generic task structure and understand the variations involved to help guide assessment so not to forget certain aspects of a task.

Operating Within the Task Space

Participants in this study varied in terms of their experience with task analysis, the number of task analyses they conducted, the tasks they analyzed as well as which aspects of the tasks they emphasized in their task analyses, and for what goals and purposes they conduct task analyses. The sample diversity reflects what literature reports in terms of the purpose of task analysis and the number of methods that exist (Stanton, Hedge, Brookhuis, Salas, & Hendrick, 2005). Participants reported using task analysis to design a system that needs to accommodate a variety of users and a variety of implementations, analyzed the performance of a specific user with specific capabilities using specific technologies, or analyzed a task with the goal of finding a job that is suitable for a person with specific capabilities and limitations.

The data of this study indicated commonalities between the foci in that participants who conducted task analyses on the same task may operate in different portions of the task space. As illustrated in Figure 6.1, a system designer may be concerned with how a variety of people will make a phone call using a range of phones (e.g., cell phone or landline). Thus, the task analysis needs to consider different person and phone variables, which lead to a number of scenarios. In contrast, an Occupational Therapist's concern is one particular person with a unique combination of injuries and the focus is on whether this person can accomplish the goal of dialing the number on one particular phone, and thus only operate with one point in the task space at any given time.

Findings from this study suggest the conception of functional task analysis as collecting, analyzing, and presenting information about a task is too narrow. Data from this study indicate that different occupations emphasize or focus on different phases of the task analysis process. Assessing performance may only be one of many goals in the process of a system designer, but the major focus of an Occupational Therapist.

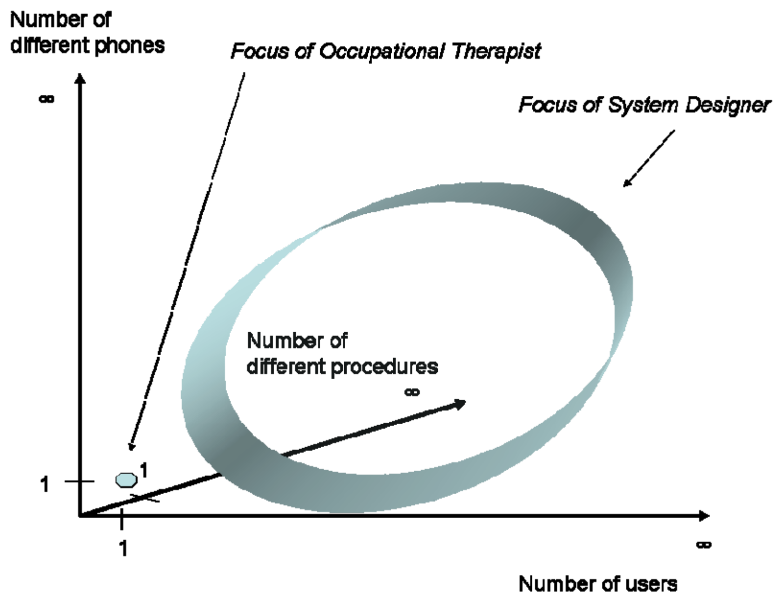

Figure 6.1: Possible task space of a system designer (broad) and an Occupational Therapist (narrow).

Skill Components as Informed by Professionals

Data gathered from professionals add to the knowledge about functional task analysis. Although the professionals who participated in this study varied in terms of their task analysis focus and approach, there were commonalities that emerged and allowed describing their approach. First, professionals in this study identified task elements by listing them from memory, asking questions, and stating assumptions. Participants brainstormed variables, recognizing that there were many variations. Some participants selected specific combinations and analyzed one particular scenario whereas others tried to be general and accommodate different scenarios. Participants also illustrated a dynamic nature of this phase of task analysis by moving subgoals around, erasing them, crossing them out, or drawing arrows. Think-aloud protocols showed that participants created depth and breadth of task analysis by asking themselves what to include, whether to include, stating assumptions about the person, the purpose of the analysis, the task requirements, the task constraints (e.g., there is a kitchen, the ingredients are there), and a person's experience (e.g., familiarity with a cooking technique). These characteristic behaviors represent valuable starting points for the development of training materials. Moreover, they illustrate distinctions in task analytic approaches as a function of the analysts' goal. The suggested skill components are:

- **Identify subgoals**
    - identify subgoal
    - delineate subgoal from other subgoals
    - state assumptions
    - ask questions
    - refer to task constraints
    - determine exact wording
    - check symmetrical subgoals
    - understand task space
    - identify objects
    - determine procedure
    - specify requirements
    - check task aspects
    - search task space
    - notice subgoal is outside boundaries

- **Create hierarchy**
    - decide to include subgoal
    - decide to exclude subgoal
    - determine location of subgoal
    - place subgoal in hierarchy
    - evaluate subgoal placement
    - adjust subgoal placement
        - move element within same level
        - move element to another level

- **Determine task boundaries**
    - determine breadth of task analysis
    - recall minimum breadth
    - recall maximum breadth
    - determine if breadth is appropriate
    - determine depth of task analysis
    - state assumptions

- **Determine task goal**
    - define goal of the task
        - question the given goal
        - determine super-ordinate goal
    - determine purpose of the task analysis
    - set scope of analysis
    - state assumptions
    - ask question
-
- **Versatility**
    - consider task variations
    - constrain task space
    - refer to task performance
    - refer to task analysis purpose
    - determine task variables
    - select task variables
    - create scenario

- **Assess performance**
    - Determine human abilities and limitations
    - Determine task performance criteria
    - Determine task performance on criteria
    - Assess performance results
    - Determine recommendations
    - Suggest recommendations

CHAPTER 7: NOVICES AT FUNCTIONAL TASK ANALYSIS

Examining the performance of experienced task analysts provides information about the desirable outcome of training and about constituent skill components. However, to understand a skill, it is also important to examine novice performance and consider groups at both ends of the skill spectrum. A different set of variables may predict novice performance compared to experienced performance, novices' prior knowledge may hinder their skill acquisition and performance, and finally, novices' errors are indicative of their problems and informative about possible underlying misconceptions.

From novices at performing a task we can learn about the challenges involved in learning the task, which can help identify underlying skill components and inform the design of training. By capturing and examining the types of errors novices make, we can determine what aspects of the task are problematic to comprehend or execute. By assessing the initial strategies that novices use we can determine whether they might benefit from training with a different strategy. Based on the knowledge that novices bring to the task we can decide whether this knowledge is supporting or hindering their task performance and/or learning, and whether to intervene. This chapter introduces topics relevant for understanding novice performance and training of novices using different instructional materials.

An Applied Scenario

Task analysis is an important tool for a Human Factors Practitioner, however, a large number of task analysis methods exists (Kirwan & Ainsworth, 1992). The scenario is of interest in which a novice takes a book, reads a short overview of a specific task analysis method, and has to apply that knowledge shortly thereafter. Hierarchical Task Analysis will be used as the example method because it is a widely used method that focuses on the analysis in terms of goals (Annett, 2004). Can novices generate the required procedural knowledge based on that brief, declarative, whole-task training? If not, what types of errors do novices make, and what are the implications for the design of training?

Drawing from the few studies that have investigated training of task analysis, the following problems encountered by novices have been identified so far: differentiating between goals and actions, omitting cognitive goals, determining the depth and breadth of the task analysis, and not thinking of different ways to complete a task (Patrick et al., 2000). However, only one or two task analyses provided the basis for these data, and criteria for examining novices' task analyses were partially dependent on each other.

Benefits of Different Training Emphases

An important question in training relates to selecting training material. Designing training materials involves choices about how to present the content, which may influence what is learned and the degree of transfer. Action training versus concept training will be used as an example, with *action training* meaning training that emphasizes the procedural steps involved in task performance, and *concept training* referring to training that focuses on the conceptual goal structure of a task.

Guided Action vs. Guided Attention

Using a computer simulated hydroponic garden control system, Hickman, Rogers, & Fisk (2007) compared training that either focused on the procedural actions of a task (guided action training) or guided the learner's attention to the relevant display concepts (guided attention training). During training, the type of training did not matter for younger adults' speed, but older adults were faster when provided with the guided action training. Both younger and older adults' performance (time and accuracy) for trained and untrained tasks were compared after training as well. Guided attention training was associated with better performance for both age groups. For trained tasks, younger adults performed the task faster, and older adults performed the tasks more accurately. For novel tasks, both age groups' performance of the guided attention condition was faster than for participants in the guided action condition, and for older adults performance was also more accurate. This illustrates that training specific procedural actions may yield short-term benefits for the trained task; however, a focus on conceptual information is associated with long-term benefits and easier transfer to novel tasks. Given that HTA requires the analysis of a variety of tasks and thus requires transfer, concept training would be recommended.

Identifying Subgoals

Action and concept training can be compared not only in terms of their benefits for learning and transfer, but also in terms of the types of inferences that are required. In *action training*, participants receive the procedural steps without the reason why. Transfer to an unfamiliar task then leads to a breakdown in the sequence of those steps, and the learner is required to draw inferences about the super-ordinate goals to solve the problem. In *concept training,* the super-ordinate goals are provided during training without the steps required to do them. Thus, the learner is required to infer the sub-ordinate goals, that is, the procedural steps of how to accomplish the goals. Both groups have to make inferences, only at different times, in different directions, and in different situations (Table 7.1).

Table 7.1

Proposed Phases of Super-ordinate and Sub-ordinate Goal Generation For Action and Concept Training During Learning, Practice, Test, and Transfer

	Learning	Practice	Test	Transfer
Action training	Procedural steps (sub-ordinate goals)	*Retrieve/ Reinforce* steps	*Retrieve/ Reinforce* steps (more practiced)	*Generate* super-ordinate goal structure, then *generate* new steps (sub-ordinate goals)
Concept training	Concept structure (super-ordinate goals)	*Generate* steps (sub-ordinate goals)	*Retrieve* steps (less practiced)	*Access* super-ordinate goal structure, then *generate* new steps (sub-ordinate goals)

Knowledge about goals has been shown to positively affect learning outcomes. For example, students were more successful at solving novel math problems when example solutions included labels that emphasized a set of steps, with abstract labels being more beneficial than superficial labels for learners with some prior knowledge. These findings led to the subgoal learning model stating that a label cues the novice to group the respective steps, self-explain why the steps belong together, and thus arrive at a subgoal for those steps (Catrambone, 1998).

However, research also showed that super-ordinate goal inferences are more likely generated online during text comprehension than sub-ordinate goal inferences (Long & Golding, 1993; Long, Golding, & Graesser, 1992). This would suggest a benefit of action training over concept training for HTA. The task of task analysis may yet be special in that it requires the learner to develop procedural knowledge for the task of task analysis while making super-ordinate and sub-ordinate inferences about another task (see Figure 7.1).

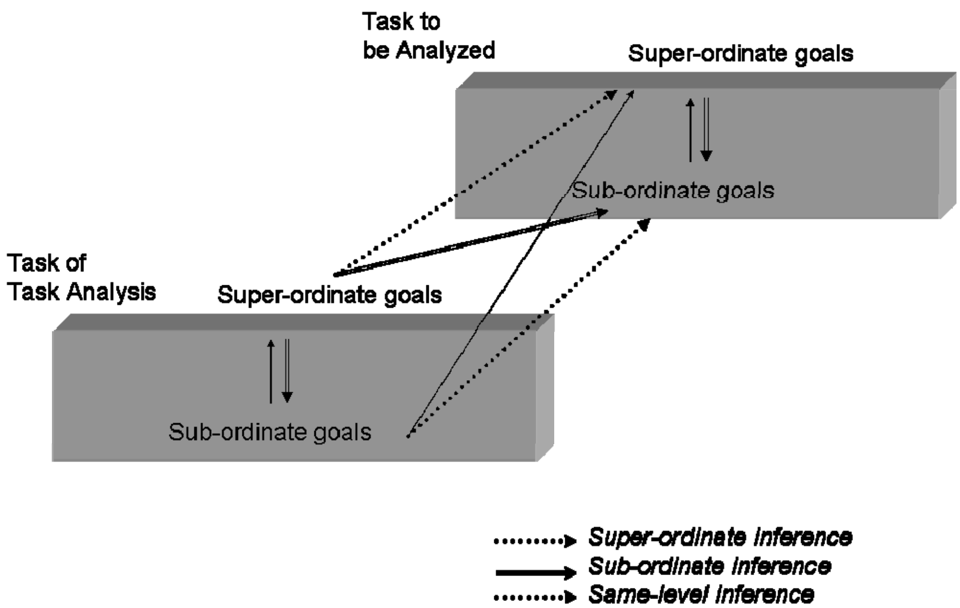

Figure 7.1. Super-ordinate and sub-ordinate inferences required for the tasks of task analysis and the task to be analyzed.

In the study by Patrick et al. (2000), novices learning HTA had problems identifying the super-ordinate goals of the task to be analyzed and instead focused on the sub-ordinate actions, suggesting that novice task analysts do not spontaneously infer the super-ordinate goals of the task to be analyzed. These are not the results one would expect if super-ordinate goal inferences were generated online. Thus, training for novices' task analysts may need to support the generation of super-ordinate goal inferences both for the task of task analysis as well as for the task that is to be analyzed.

Meeting The Novice's Challenge – Training Material

Previous literature on training HTA did not specify the content used for training (Patrick et al., 2000; Stanton & Young, 1999), and the question remains what training materials to use for the declarative training. The declarative training content chosen for this study was an introduction to HTA (Shepherd, 2001), which outlines the main concepts of HTA. However, further instructions were added to understand if different visual presentations aid learning HTA.

Visual Presentations

Visual presentations often supplement a text to help and illustrate concepts. Adding a visual presentation format has been show to improve performance on procedural tasks (e.g., bandaging a wound), with the combination of line drawings and text being as effective as video and more beneficial for learning than either line drawing, text, or a still video. However, this effect may be due to the added information value (Michas & Berry, 2000) and may be facilitated by the concrete, procedural nature of the task. Some tasks lend themselves well for visualization using an iconic diagram. However, providing additional information for an abstract task is not as easy.

Spatial Diagrams

HTA can be described as an abstract, complex cognitive task that does not lend itself easily to a concrete image or visualization. One way of presenting abstract information is in form of a spatial diagram, which is an abstract diagram and depicts abstract concepts. Matrices, networks, and hierarchies are three types of spatial diagrams (Novick, 2006). A *matrix* is a two-dimensional display of static information, and the prominent feature is that it shows static relations between pairs. The *network* is a graph or path diagram that depicts dynamic information with both global information and local connections. The *hierarchy* is a tree diagram that informs about the rigid, global structure (Novick; Novick & Hurley, 2001; for examples see Figure 7.2).

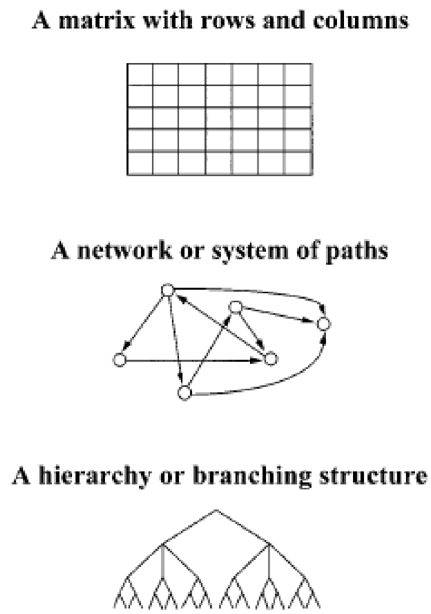

Figure 7.2. Examples of matrix, network, and hierarchy abstract diagram (from Novick & Hurley, 2001).

Mapping Spatial Diagrams to Task Properties

But how can spatial diagrams be used to visualize HTA, and which of these different visualizations would be most effective for a novice to learn HTA? Will these diagrams be associated with different kinds of knowledge and produce different errors? These different diagrams emphasize different aspects of a task. A task typically requires sequential steps to be executed, decisions to be made, and consists of interrelated concepts. To understand the relative benefits of the different types of spatial diagrams for learning HTA, the three types of abstract diagrams were mapped onto different aspects of HTA: goals (concepts), steps (actions), or rules in form of decisions-actions. The purpose of HTA is to determine the goal structure of a task, which is a hierarchy diagram, or concept map. A list of steps can be used as an example of the matrix-type diagram as it is a closely-linked, actual sequence of elements that is executed. The process of conducting HTA can also be described as network or path diagram with its if-then rules.

More specifically, a list of steps can be thought of as a 2-column matrix that consists of static sequence of steps. The benefit of procedural instructions is that learners do not need to generate their own but can focus on following and learning the routine. However, transfer to a task may prove difficult if the instructions do not cover the particular circumstances of that task. The expectation is then that a novice who receives a list of steps will focus on the specific, sub-ordinate level of a task.

Secondly, the paths and connections of HTA can be visualized in form of a decision-action diagram, that is, a network type of a spatial diagram. The main benefit of this diagram is that they illustrate the decisions and actions, that is, if-then-else rules that should support creating a more sophisticated mental model of conducting an HTA, that is, both global information as well as local connections. The expectation here is that a novice who receives a network-type decision-action diagram will focus on the rules that connect different paths and bind super-ordinate and sub-ordinate levels.

Lastly, a concept map is an example of a hierarchy-type spatial diagram that illustrates elements and relationship between these elements on various levels. Research has shown the benefits of constructing concepts maps for solving problems, which has lead to guidelines for their constructions (e.g., Lee, Baylor, & Nelson, 2005). However, it is unknown what would be learned about HTA from an already created concept map. The expectation is that the learner's focus is directed towards the super-ordinate level of a task and thus be more general.

CHAPTER 8: STUDY 2 - METHOD

Participants

Thirty-eight undergraduate students from the Georgia Institute of Technology participated in this experiment. Data for two participants were excluded because one was not a native English speaker and another did not complete any of the task analyses within the allotted timeframe of 15 minutes. The final data set included 11 males and 25 females. Participants were recruited via the School of Psychology recruitment website (Experimetrix) and received one credit hour per hour of participation. The experiment lasted approximately two hours.

Participants ranged in age from 18-24 years (M = 20.6 years, SD = 1.5) and had normal or corrected normal vision of at least 20/40 both near and far vision. The sample consisted of 27 White/Caucasian (75%), 4 Black/African American (11%), 4 Asian (11%), and 1 Multi-Racial participant (3%). A one-way ANOVA of the ability test data showed that participants in the experimental conditions did not differ in their general abilities (Table 8.1).

Table 8.1

Participant Characteristics (N = 12 per condition)

Training condition	Steps		Decision-Action		Concept Map		*p*
	M	*SD*	*M*	*SD*	*M*	*SD*	
Age	20.42	1.78	20.50	1.62	20.83	1.19	---
Digit Symbol Substitution[a]	95.33	12.71	95.33	15.59	105.08	15.87	.19
Reverse Digit Span[b]	8.92	1.88	8.58	2.02	7.75	1.66	.30
Shipley Vocabulary[c]	32.75	3.14	32.67	3.17	32.00	3.46	.83

Note. Alpha level was set at .05; none of the group differences were significant.
[a]Number correct in 2 minutes out of 120 (Wechsler, 1997). [b]Number correct out of 14 (Wechsler).
[c]Number correct out of 40 (Shipley, 1986).

Selection Criteria: Prior Experience with Task Analysis

Being a novice at task analysis was one requirement for participation and assessed through three questions in the Demographics and Experience Questionnaire: “Have you heard about task analysis before this study?”, “Have you conducted a task analysis before this study?”, and “Have you taken a course that discussed task analysis?”. Task analyses were also inspected as to whether they were in a format required by HTA. Participants were considered novices if they did not report having experience conducting a task analysis outside of class and their initial task analysis did not have an HTA format.

No participant was excluded based on prior experience. Twenty five percent of all tested participants had heard about task analysis prior to the experiment, mainly covered as a topic in class. More specifically, task analysis was covered in a wide variety of program areas such as management, psychology, computer science, and industrial design.

Diversity of Majors

Participants were enrolled in undergraduate programs and reflect the diversity of majors at the Georgia Institute of Technology: Aerospace Engineering (1), Applied Biology (1), Applied Mathematics (1), Biochemistry (1), Biology (7), Building Construction (1), Computer Science (3), History, Technology, and Society (2), Industrial Design & Systems Engineering (4), Industrial Engineering (4), Management (3), Mathematics (1), Mechanical Engineering (1), and Psychology (6).

Materials

Introduction to Hierarchical Task Analysis

All participants received a three-page handout that provided a general introduction to HTA as can be found in a human factors methods book (see Appendix D.1). This introduction was adapted from Shepherd (2001, p.1f) and provided a brief overview of the history and goals of HTA and introduced the main concepts such as the hierarchical nature of HTA, goals, subgoals, constraints, and plans for accomplishing the goal. This study focused on the content of the task analysis and not the adherence to a visual representation. Thus, the visual example of the text was removed along with any references to it. The text was slightly altered in terms of grammar and content.

Condition-Specific Instructions

Participants in each training condition received an additional handout that emphasized different aspects of HTA. In the Steps training condition, the additional information focused on the sequence of steps involved in conducting HTA (adapted from Stanton, 2006; see Appendix D.2). The additional information in the Decision-Action Diagram training condition was a diagram illustrating the flow of decisions and actions involved in conducting a HTA (taken from Shepherd, 2001, see Appendix D.3). Participants in the Concept Map training condition received a handout in which goals and subgoals involved in HTA were presented in the form of a concept map. The concept map (see Appendix D.4) was an attempt to create a high-level HTA of HTA, based on the information stated by Shepherd.

A comparison chart revealed that initially, not all of the three additional instructions touched on the same topics. The following changes were made to ensure that participants in the three conditions were exposed to the same topics: The Decision-Action Diagram was amended by information about defining the purpose of the analysis and gathering data, and the Steps condition was amended to include information about determining if the redescription was equivalent.

Questionnaires

Participants completed three questionnaires over the course of the experiment. The Demographics and Experience Questionnaire (Appendix D.5) assessed general demographic information as well as information about educational background and prior experience with task analysis. The purpose of these questions was to assess participants' prior knowledge about task analysis and thus serve as a criterion for potential exclusion from data analysis.

The Task Questionnaire probed for information about familiarity with each of the tasks that participants had analyzed (Appendix D.6). The Task Analysis Questionnaire first asked participants to list five main criteria of HTA, the analysis of which allowed gauging of the declarative knowledge acquired about HTA. Following this, participants rated how difficult they found each of the six task analyses, how confident they were in their result, and were asked to provide a brief description about how they conducted the task analysis. General questions followed with the goal to elicit strategic information about how participants identified goals and subgoals, expressed order, and decided on the breadth and depth of the analysis (Appendix D.7).

Equipment and Set-up

Participants conducted their task analyses on 11 x 17, off-white paper, placed in landscape format in front of them. They were allowed to use as many pages as they needed and reposition the paper in a format they preferred.

Procedure

Before the experiment, participants were randomly assigned to one experimental condition and counterbalance version, with the rule that no more than two participants were assigned to the same experimental condition and counterbalance version in a row. Participants were individually tested. After reading and signing the informed consent form (Appendix D8), participants completed the test for far and near vision (Snellen acuity test) and the ability tests: Digit-Symbol-Substitution test for perceptual speed (Wechsler, 1997), Reverse Digit Span for memory span (Wechsler), and the Shipley Vocabulary test for verbal ability (Shipley, 1940). (See Appendix D.9 for an overview of the experimental protocol).

Following the ability tests, participants' first assignment was to perform a task analysis of a given task to obtain a baseline measure of how participants approached a task analysis without experimental instructions. The first task to be analyzed was either *making sandwich* (cooking) or *making phone call* (communication) and counterbalanced across participants. If participants had questions, they were instructed to work to the best of their knowledge and understanding.

After the initial task analysis, participants received the Introduction to Hierarchical Task Analysis. Participants were told to study the information carefully so they have a good understanding of the method before starting to apply it. To motivate participants to study the material thoroughly they were first asked to review the material. Once participants gave feedback that they were ready to move on, they were asked to review the material again (for 10 minutes) to ensure they knew it well. Participants were allowed to spend a maximum of 15 minutes with the Introduction to Hierarchical Task Analysis. When participants had finished reviewing the Introduction to Hierarchical Task Analysis, they received the Condition-Specific Instructions for their experimental condition. Participants were required to spend at least 5 minutes with the Condition-Specific Instructions to ensure minimum time across all conditions and had up to 15 minutes to study the material. Participants could write on the paper.

Once the familiarization phase was completed, participants conducted two more task analyses of the same domain. After a 3-minute break, participants completed the Demographics and Experience Questionnaire and a contact information sheet before completing the three task analyses of the second domain. Participants had 15 minutes to complete each task analysis, and were allowed to refer to the Introduction to Hierarchical Task Analysis as well as the Condition-Specific Instructions while working on their task analyses.

After concluding the task analysis phase, the instructions were removed and participants completed the Task Questionnaire, the Task Analysis Questionnaire (15-20 minutes), and were debriefed (see Appendix D.10). See Figure 8.1 for the general flow of the study.

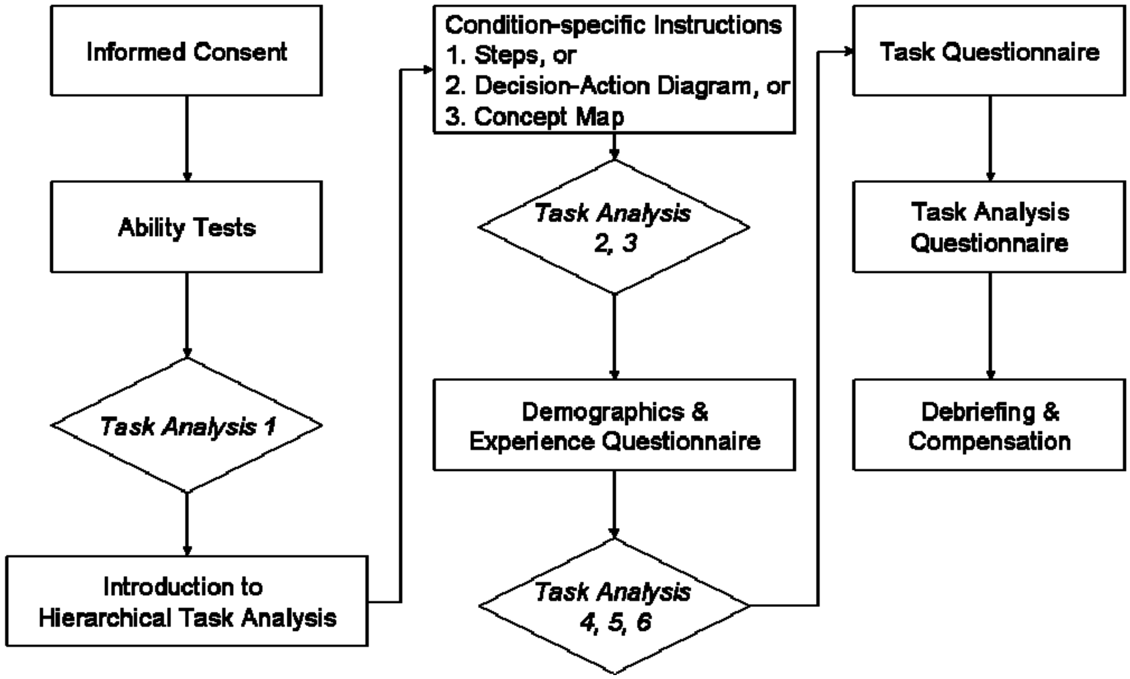

Figure 8.1. Flow of activities in study 2.

Design

This experiment was a between participant design with three experimental training conditions: Steps, Decision-Action Diagram, and Concept Map. The dependent variables included measures of declarative and procedural knowledge. Declarative knowledge was determined via the Task Analysis Questionnaire. Procedural knowledge assessment was based on the task analyses participants produced. The experiment included repeated measures as participants analyzed a total of six tasks, arranged in two counterbalance versions (see Chapter 2).

CHAPTER 9: STUDY 2 - DATA ANALYSIS AND RESULTS

Data analysis focused on understanding the procedural and declarative knowledge participants acquired during the experiment. The task analyses that participants produced provided the basis for assessing procedural knowledge. The main questions were what novices did before instruction, after instruction, whether experimental groups differed in their performance, and what errors participants made. The features of HTA that participants recalled at the end of the experiment comprised the assessment of declarative knowledge and misconceptions.

Task Familiarity - Material Check

Participants rated each task on a 5-point Likert-type scale in terms of how familiar they were with the task (1 = not very familiar, 5 = very familiar) and how frequently they performed each task (1= never, 5 = daily). Table 9.1 shows the familiarity and frequency ratings for each task. As expected participants were very familiar with the tasks of *making phone call*, *making sandwich*, *making breakfast*, and *arranging meeting*. Also, as intended, participants were unfamiliar with the tasks of *making Vetkoek* and *sharing pictures* using Adgers (*Mdn*=1). Frequency ratings were in line with familiarity ratings: high for the high-familiar tasks and low (never) for low-familiarity tasks.

Table 9.1

Measures of Central Tendency and Spread for Familiarity and Frequency Ratings

Domain	Familiarity[a]			Frequency[b]		
	Mdn	*M*	*Range*	*Mdn*	*M*	*Range*
Cooking						
making sandwich	5.00	4.83	2	3.00	2.92	1-5
making breakfast	5.00	4.83	1	4.50	4.19	2-5
making Vetkoek	1.00	1.00	0	1.00	1.00	1
Communication						
making phone call	5.00	5.00	0	5.00	4.97	4-5
arranging meeting	4.00	3.86	4	3.00	3.11	1-5
sharing pictures	1.00	1.00	0	1.00	1.00	1

Note. [a]The Likert-type scale ranged from 1 (not very familiar) to 5 (very familiar. [b]The scale consisted of 1 (never), 2 (yearly or less often), 3 (monthly), 4 (weekly), and 5 (daily).

A repeated measure ANOVA (task by condition by version) was conducted to verify that the tasks did not differ in familiarity across experimental conditions. Because there was no or limited variability for some tasks, the sphericity assumption did not hold. The reported F-values and degrees of freedom are Greenhouse-Geisser corrected. None of the interactions were significant (p=.07 for 3-way interaction, p=.37 for task by version, p=.19 for task by condition, and p>.05 for condition by version). Familiarity ratings differed between tasks (main effect of task, F= 711.79, df=1.7, p<.01, η^2_p=.96), but not between experimental conditions (p=.14) or counterbalance version (p=.89). Thus, as expected, the tasks spanned a range of familiarity. Participants were unfamiliar with *making Vetkoek* and *sharing pictures* using Adgers (low familiarity) but were very familiar with *making sandwich* (high familiarity). *Making breakfast* and *arranging meeting* received intermediate to high familiarity ratings.

Procedural Knowledge

Overview

The overall questions centered on what categories described novice performance before and after training and what errors participants made. Task analyses were coded on features of HTA to determine whether participants created and demonstrated the necessary procedural knowledge from the instructions. More specifically, the first question of interest was what were the characteristics of novices' initial demonstration of task analysis without instructions? The first task analysis that participants conducted provided the basis of this investigation. The second question was how performance differed before and after training, assessed by comparing performance of the first and fourth task. Did participants who read the instructions create deeper and more general task analyses for *making sandwich* and *making phone call* than participants who analyzed the task before training? The third question generally targeted what participants learned from training, based on the analyses of all the five task analyses conducted after training. The fourth question focused on comparing task analyses conducted for familiar and unfamiliar tasks, expecting task analysis of unfamiliar tasks to be more general than familiar ones, keeping in mind the limitations in interpretation imposed by the fixed counterbalance order.

Of interest was also, whether the type of training influenced novice performance. However, training conditions did not differ significantly on most comparisons, indicating that with this brief declarative training the type of instruction did not matter for the initial expression and assessment of procedural knowledge. Thus, results include combined information across conditions where appropriate.

Coding Scheme

The coding scheme was based on the categories brought forward by Patrick et al. (2000), and categories were defined so they could be assessed independently of each other. Task analyses were coded on six criteria (see Table 9.2 for an overview of the coding scheme and Appendix E.1 for description and examples).

Table 9.2

Overview of Coding Scheme for The Task Analyses

Criterion	Definition
1. Hierarchy dimensions	a) What is the breadth of the task analysis? b) What is the depth of the task analysis ?
2. Goal	Was the main goal stated?
3. Subgoal	a) Was the label *subgoal* used? b) What subgoals were identified?
4. Plan	a) Was the label *plan* used? b) How was sequence expressed? (e.g., words, numbers, flow chart)
5. Criteria	Were criteria mentioned to determine whether the goal was reached satisfactorily?
6. Specificity	Was the task analysis general or specific?

To assess hierarchy dimensions (criterion 1), coders assessed the breadth and depth of the task analyses. Task analyses were coded as to whether participants mentioned the high-level goal (criterion 2). Subgoal-related inspection focused on whether the label "subgoal" was mentioned and what subgoals participants identified (criterion 3). Task analyses were also inspected for two aspects of the plan (criterion 4): was the label "plan" used and what style participants chose to represent order, given the lack of information as to the format of HTA. Task analyses were coded for whether participants mentioned criteria (criterion 5), and for how versatile they were (criterion 6), that is, if they were tied to a specific technology or general and thus applicable to a range of implementations. Overall agreement was 79 % (see Appendix E.2 for reliability values).

Novices' Untrained Performance: Task #1

The first task was either *making sandwich* (counterbalance version 1) or *making phone call* (counterbalance version 2). As for the first criterion, hierarchy dimension, task analyses of *making sandwich* had an average breadth of 5.5 subgoals (*SD*=2.4) and an average depth of 1.3 subgoals (*SD*=.5). Comparable, *making phone call* had an average breadth of 4.2 subgoals (*SD*=1.7) and a depth of 1.1 (*SD*=.3). Only one participant mentioned the main goal in the initial task analysis (criterion 2), which can create problems if the context gets lost.

Data analysis of the third criterion, subgoals, showed that no participant mentioned the label *subgoal* in any of the initial task analyses, which shows that using the label subgoal is not part of a novices' spontaneous repertoire. Participants identified about twice as many subgoals for *making sandwich* (154) compared to *making phone call* (79) with a focus on lower-level goals (222 out of 233 total). This illustrates that novices do not spontaneously analyze a task on the level of super-ordinate goals.

For the fourth criterion (plan), participants did not mention the label *plan* at all. Task analyses showed a wide variety of formats: bulleted lists, numbered lists, and other list types, flowcharts, pictures, and a combination of these (see Table 9.3). One participant initially acted out the task, and three participants used a pure picture format for the initial task analysis. This illustrates that participants had a range of ideas of how to represent task analysis, and chose formats that closely tied the content of task elements with their sequence.

Table 9.3

Plan Styles for Task 1 (Raw Counts)

	Sandwich	Phone	Total
Bulleted List	0	2	2
Numbered List	7	6	13
List Other	3	3	6
Picture	2	2	4
Flowchart	0	3	3
Combination	6	2	8

Note. Eighteen participants each analyzed the tasks of *making sandwich* and *making phone call*.

Overall, only 2 of the 36 initial task analyses included some mentioning of criteria (criterion 5), showing that novices did not associate stating criteria with task analysis. For criterion 6, versatility, data showed that only 27.8% of the first task analysis were general. Participants who analyzed the task of phone received a higher number of general codes than the task of sandwich (see Table 9.4). A chi-square analysis showed that the distribution between specific and general was not equal between the two tasks (χ^2= 8.89, *df*=1, *p*<.00). Residuals showed that responsible for this effect was that *making sandwich* received more specific codes and fewer general codes than would be expected by equal distribution (see Appendix E.3, Table E.2). Inspecting the raw data showed that four out of six participants in the Decision-Action Diagram condition produced a general task analysis of phone and thus are mostly responsible for the higher number of general phone task analyses.

Table 9.4

Versatility for Task 1

	Sandwich	Phone	Total
Specific	15	11	26
General	3	7	10
Total	18	18	36

Note. Eighteen participants each analyzed the tasks of *making sandwich* and *making phone call*.

Novices' Trained Performance: Task #1 Before and After Training

The next question was how untrained and trained performance differed. The task analyses of *making sandwich* and *making phone call* of participants who received this as their first task (before training) or fourth task (after training) served as the basis for this comparison.

Criterion 1: Hierarchy. Figure 9.1 shows a comparison of breadth and depth of the tasks *making sandwich* and *making phone call* between participants who analyzed the task before training and participants who analyzed those tasks after training. Of particular interest was whether trained task analyses were deeper. As mentioned earlier, participants' first task analyses of *making sandwich* and *making phone call* were only one or two levels deep. Participants who conducted a task analysis of the same tasks after training created task analyses that had a greater depth (see Appendix E.4 for breadth and depth data before and after training). This difference in depth was significant for both *making sandwich* ($F(1, 36) = 15.85$, $p<.01$, $\eta_p^2=.346$) and *making phone call* ($F(1, 36) = 16.81$, $p<.01$, $\eta_p^2=.359$). Thus, participants illustrated a general understanding of the importance of a hierarchy to HTA. The average breadth of the task analyses conducted by participants before training and participants after training did not differ for either *making sandwich* (p=.64) or *making phone call* (p=.81). However, as Figure 9.1 shows, there were participants whose task analyses were not within the breadth boundaries of 3-8 elements.

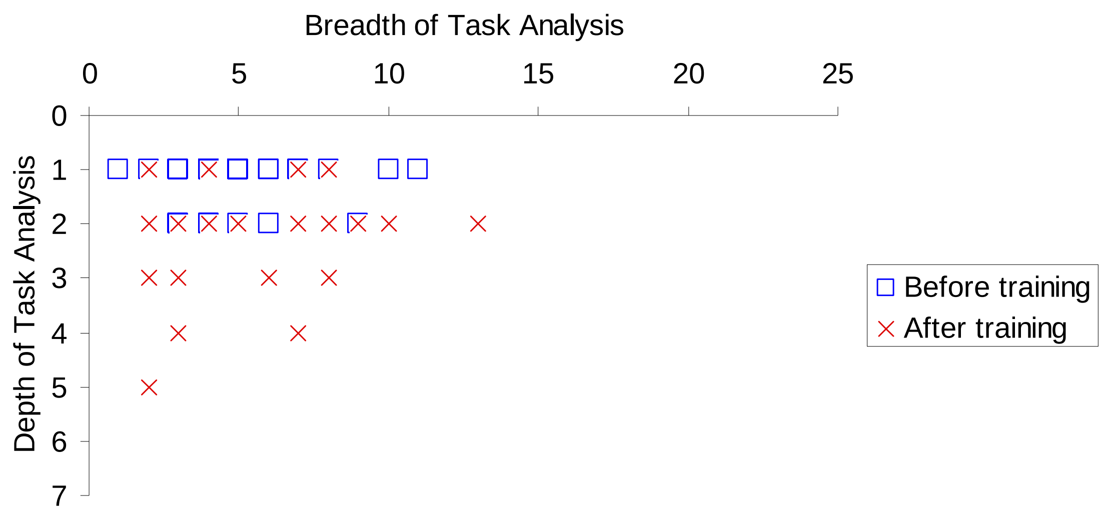

Figure 9.1: Breadth and depth of task analysis (TA) for *making sandwich* and *making phone call* before and after training.

Criterion 2: Goal. Only one participant mentioned the high-level goal before training; however after training 86.1% of the tasks analyses contained the high level goal (31 out of 36). Chi-square test showed that participants mentioned the main goal significantly less often compared to maximum (χ^2= 34.78, df=1, p<.01), and residuals showed that responsible for this effect was the low number of mentioned goals before training, but not after training (see Appendix E.3, Table E.3). This illustrates that participants who received training recognized the importance and incorporated mentioning the goal in their procedure of conducting HTA (see also Table 9.5).

Table 9.5

Number of Making Sandwich and Making Phone Call Task Analyses that Contained Goal

	Making sandwich	Making phone call	Total
Before training	0	1	1
After training	15	16	31

Note. The maximum total for *sandwich* and *phone* is 18 each.

Participants did not only state the goal verbatim as shown to them ("Making a peanut-butter jelly sandwich") but also adjusted it ("Making a sandwich", "Making a PBJ sandwich so it tastes yummy"). This is important to know because changing the goal of the task may lead to an analysis different from requested.

Criterion 3: Subgoal. No participants had mentioned the subgoal label in their task analysis before training. Compared to this untrained performance, 30.6% of task analyses of the same tasks (*making sandwich* and *making phone call*) conducted after training showed the label *subgoal*. This is larger in number; however, still significantly below what would be expected based on maximum (χ^2= 17.61, *df*=1, *p*<.01).

The number of subgoals participants identified after training was almost twofold compared to the number mentioned before training (see Table 9.6). However, the increase in number was not associated with a shift in proportion. Participants identified the same proportion of main level subgoals to lower level subgoals for *making sandwich* (*p*=.72) and *making phone call* (*p*=.62).

Table 9.6

Number of Subgoals Identified for Making Sandwich and Making Phone Call Before and After Training

	Making sandwich	Making phone call	Total
Before training			
- Main level subgoals	4	7	11
- Lower level subgoals	150	72	222
- Extra	4	13	17
After training			
- Main level subgoals	6	20	26
- Lower level subgoals	284	164	448
- Extra	0	15	15

Note. 18 participants analyzed the task of sandwich (phone) before and 18 participants analyzed the same task after training.

The vast majority of the subgoals related to the task of *making sandwich* focused on "following the recipe", whereas most of the subgoals related to the task of *making phone call* focused on "connect to receiver", followed by "determine receiver " related verb-noun pairs. This illustrates that although the breadth of the analysis was within the suggested parameters, participants focused their analysis only on some aspects of a task.

Criterion 4: Plan. The label *plan* was not mentioned by any of the participants in their initial task analysis. In comparison, 33% of task analyses of *making sandwich* and *making phone call* completed by participants who analyzed these task after training contained the label; which is still significantly lower than would be expected based on maximum (χ^2= 16.11, df=1, p<.01).

The variety of plan styles remained. Two styles that appeared after training was text in form of a paragraph and a hierarchy. Participants most often used a list style for their task analyses both before training and after training. Four participants used only pictures in their initial analyses. Participants also used pictures after training, however, only in combination with another style, the flowchart being the favorite choice. This illustrates that participants think of different ways to express HTA and move from visual to verbal formats.

Criterion 5: Criteria. Only 2 of the task analyses completed before training included mentioning of criteria, compared to 21 out of 36 of the same 2 tasks completed after training (58.3%). Despite the higher number of criteria mentioned by participants who had received training, criteria were mentioned significantly less than maximum both before and after training (χ^2= 38.72, df=1, p<.01), and thus indicate room for improvement.

Criterion 6: Versatility. Only 27.8% of the untrained task analyses were general (10 of 36; 17% of *making sandwich*, 39% of *making phone call*). After training, 41.7% of task analyses for those same tasks were general (33% of *making sandwich*, 50% of *making phone call*, see Table 9.7). This increase was not significant (p=.08), and despite this increase in numbers, task analyses conducted by participants with and without training were significantly less often general compared to maximum (χ^2= 31.72, df=1, p<.01), which suggests that this brief training was not sufficient.

Table 9.7

Number of Making Sandwich and Making Phone Call Task Analyses that were General Before and After Training

	Making sandwich	Making phone call	Total
Before training	3	7	10
After training	6	9	15

Note. The maximum total for *sandwich* and *phone* is 18 each.

Summary performance before and after training. Participants who completed the task analyses of *making sandwich* and *making a phone call* after training showed better performance on some aspects of HTA, but not all. The breadth of analysis did not differ before and after training, however, participants who received training produced deeper task analysis than participants without training. This is partial success, as novices illustrated an understanding that HTA is about hierarchy. The goal, another main feature of HTA, was mentioned more often by participants who received training. This was the only feature that was not significantly different from maximum expected after training. A potential source for errors appeared as participants not only stated the goal but also adjusted it.

Stating the plan and subgoal labels was higher after training, indicating an awareness of these features of HTA, but not for all participants who received training. Participants who received training did not mention criteria more often or created significantly more general task analyses than untrained participants, suggesting that training in these criteria was not sufficient.

Novices' Trained Performance: Tasks #2- #6

The next set of analyses addressed the question whether participants' performance was stable after training across a number of tasks.

Criterion 1: Hierarchy. After training, the average breadth (*M*=4.38, *SD*=2.55) remained within the parameters of three to eight elements (see Table 9.8). A repeated measure ANOVA for breadth and depth of the five task analyses conducted after training (by their task order) showed no significant differences in breadth or depth between tasks ($p_{breadth}$=.50, p_{depth}=.12), training conditions ($p_{breadth}$=.19, p_{depth}=.21), or counterbalance versions ($p_{breadth}$=.55, p_{depth}=.59). None of the interactions was significant. Although the tasks did not differ in their average breadth and were within the desired range, participants chose a width that was close to the narrow end of the recommended range. Also, as can be gleaned from Table 9.8, participants continued to produce task analyses that were clearly outside the range in both directions, that is, too narrow or too broad.

Table 9.8

Breadth and Depth of Task Analyses # 2-6 (After Training)

	Breadth			Depth		
	M	*SD*	*Min-Max*	*M*	*SD*	*Min-Max*
Cooking						
Sandwich	5.94	2.94	2-13	2.17	.79	1-4
Breakfast	4.53	3.57	1-15	2.14	.83	1-4
Vetkoek	3.67	1.53	1-7	1.92	.84	1-4
Communication						
Phone	4.06	2.44	2-10	2.33	1.19	1-5
Meeting	4.25	2.21	1-12	2.06	.79	1-4
Adgers	4.44	2.08	2-10	2.14	.90	1-4
Total	4.38	2.55	1-15	2.10	.87	1-5

Note. Data for sandwich and phone are only from participants of one counterbalance version. All other tasks include data from both counterbalance versions. Total number of task analyses

Given that participants did not have specific information for analyzing unfamiliar tasks it was also of interest whether task familiarity was associated with greater depth, that is, did participants go deeper when there was more information available? A repeated measure ANOVA for familiar and unfamiliar tasks (tasks 2, 3, 5, and 6) showed no significant differences for breadth and depth for tasks ($p_{breadth}$=.26, p_{depth}=.30), training conditions ($p_{breadth}$=.69, p_{depth}=.22), or counterbalance versions ($p_{breadth}$=1.0, p_{depth}=.60). This suggests that participants have developed and settled into what they consider a general breadth and depth of an HTA.

Criterion 2: Goal. Participants mentioned the high-level goal in 88.3 % of the task analyses conducted after training. Chi-square analyses confirmed that the high-level goal was not mentioned significantly less often than would be expected when considering the 5 task analyses completed after training (*p*=.13). Also, as observed earlier, participants adjusted the main goal, mentioning the goal as given to them in 71.1% of the task analyses and a variation of the goal in 17.2% of the cases. Figure 9.2 shows that participants illustrated on a number of tasks the importance of mentioning state the high-level goal (and a variation of it).

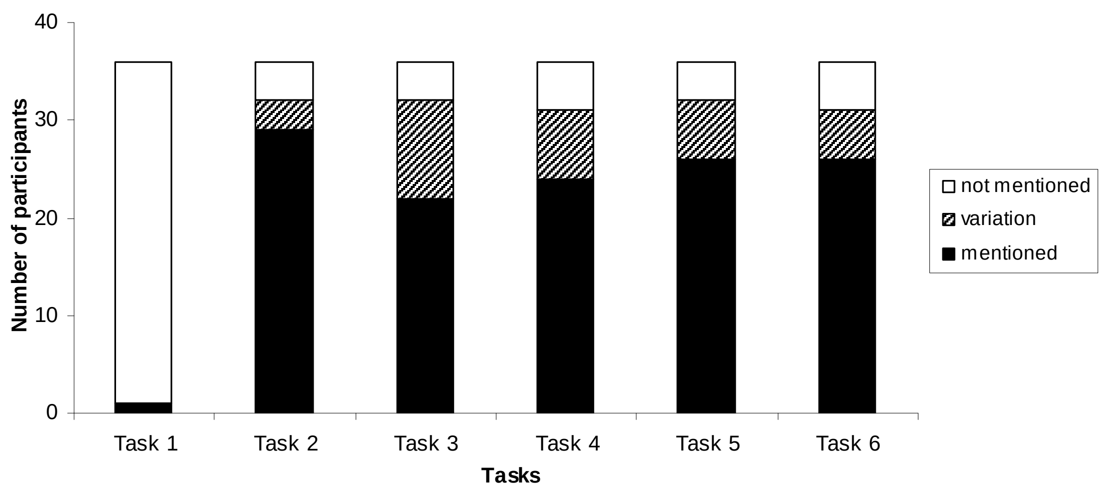

Figure 9.2: Number of participants (*N*=36) mentioning the goal in their task analyses. Note that Task 1 was completed before training.

Criterion 3: Subgoal. Overall, participants mentioned the label more often after training, but still in only 33.9% of the 5 task analyses completed after training (see Table 9.9), which is significantly less compared to maximum expected (χ^2= 79.68, *df*=2**,** *p*<.00). This illustrates an increased awareness of the importance of subgoals but labeling it not as a necessary feature of HTA.

Table 9.9

Percent of Task Analyses That Included the Label "Subgoal"

	No training	After Training						
Condition	Task 1	Task 2	Task 3	Task 4	Task 5	Task 6	Total	%
Total	0	12	12	11	12	14	61	28.24

Note. Maximum total per task was 36 and overall 217.

Subgoals were also inspected with respect to the content. Overall, 2.417 verb-noun pairs were coded for all 6 task analyses. As illustrated in Figure 9.3, most of these verb-noun pairs pertained to subgoals on lower levels.

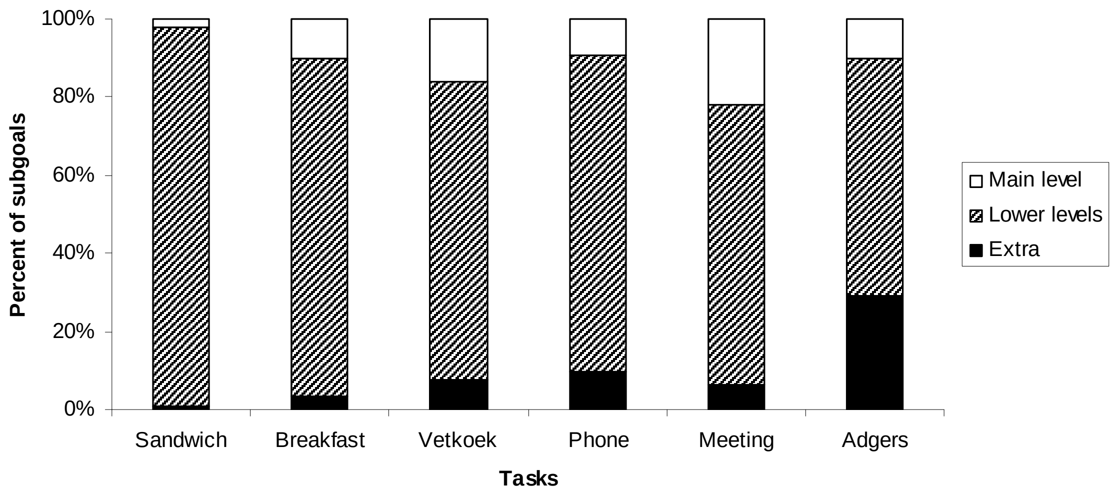

Figure 9.3: Relative proportion of verb-noun pairs situated at the main level, lower levels, or extra (not included in the master task analyses).

A larger number of subgoals overall was mentioned for familiar and general tasks of *making breakfast* and *arranging meeting* than the other tasks, except for the task of *making sandwich* (see Table 9.10). A larger number of subgoals was also mentioned for familiar and general tasks of *making breakfast* and *arranging meeting* compared to the unfamiliar tasks of *making Vetkoek* and *sharing pictures.* A Chi-square analysis was conducted to determine if participants identified more main level subgoals for the unfamiliar tasks compared to the familiar tasks. However, the results showed that participants identified the same proportion of main level subgoals (15.9%) to lower level subgoals (84.1%) for familiar and unfamiliar tasks (p=.82). This indicates that participants chose a lower level analysis even for tasks that they were unfamiliar with and did not have specific details.

Table 9.10

Number of Subgoals Identified for All Tasks

	Main level subgoals	Lower level subgoals	Total subgoals	Extra
Cooking				
Sandwich (before)	4	150	154	4
Sandwich (after)	6	284	290	0
Breakfast	57	488	545	19
Vetkoek	58	275	333	27
Communication				
Phone (before)	7	72	79	13
Phone (after)	20	164	184	15
Meeting	90	298	388	26
Adgers	35	206	241	99
Sum	277	1937	2214	203

Note. The basis for these pairs are 217 task analyses.

Subgoals and extra subgoals for the unfamiliar tasks of *sharing pictures* and *making Vetkoek* centered around the fact that the task was unfamiliar and participants had to get ready for the task. *Making Vetkoek* had more verb-noun pairs associated with "obtaining a recipe" and "learning" about what Vetkoek is, compared to the other cooking tasks. Task analyses of *sharing pictures* were associated with mentioning of downloading and installing Adgers along with learning how to use it. This suggests that participants let the perspective of the task performer inform their task analysis.

Criterion 4: Plan. Overall, only 36.1% of the task analyses after training (65 of 180) included the label *plan* (see Figure 9.4). Participants used the label plan less often than would be expected if they had used it for all 5 task analyses after training (χ^2= 76.82, *df*=2, *p*<.01). Differences between training conditions were found in that participants in the Concept Map condition used the label most often (45.8%, see Appendix E. 5) and significantly more so than participants in the Steps condition (25.0%) and Decision-Action Diagram condition (19.4%) (χ^2= 9.26, *df*=2, *p*=.01). Note, that no participant did this for task 1. This illustrates that participants were trying to incorporate their understanding of the importance of the plan and that participant in the Concept Map condition chose to do so more often by using the label *plan*.

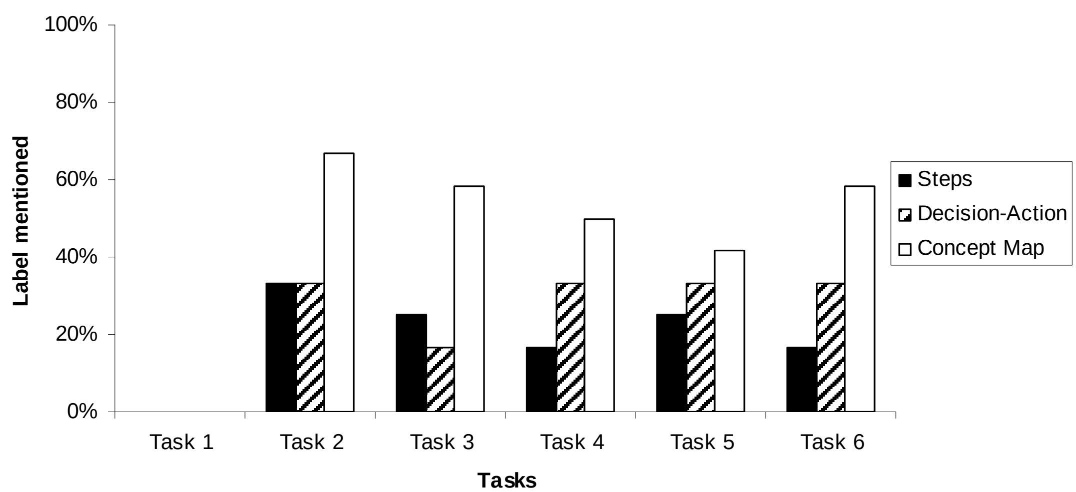

Figure 9.4: Percent of participants using the label *plan* in their task analyses.

Over the course of the five task analyses, participants most often used a list style for their task analyses both before and after training, not including participants combining list styles with another style (see Table 9.11). A combination of styles was the second most frequent choice, and here the flowchart and the numbered list were the two styles participants combined most often with another style. This being said, training conditions differed in their top two choices (χ^2= 41.46, *df*=6, *p*<.01). Lists were the top choice for participants in the Concept Map condition (66%). Participants in the Steps condition had the highest proportion of flowchart or hierarchy-type formats of all training conditions (29% combined). The two participants who actually used a hierarchy format typical for HTA (after training) were in the Steps condition. Participants in the Decision-Action Diagram condition accounted for most of the combination of styles (32%).

Table 9.11

Percent of Task Analyses Using Which Plan Style for All Tasks

	Training Condition			
Plan Style	Steps	Decision-Action	Concept Map	Total
List style	51.4	59.7	66.7	59.3
Flowchart/hierarchy	29.2	5.6	1.4	12.0
Combination	8.3	31.9	23.6	21.3
Other	11.1	2.8	8.3	7.4
Total	100.0	100.0	100.0	100.0

Note. Each of the 36 participants completed six task analyses

Criterion 5: Criteria. Criteria were mentioned in 65% of the 5 task analyses completed after training, significantly less often than would be expected if they did it for all five task analyses after training (χ^2= 23.65, *df*=2, *p*<.00). Thus, even though participants continued to illustrate this main feature of HTA, their performance indicates that further training is required.

Criterion 6: Versatility. Considering all 5 task analyses conducted after training, a total of 107 of 180 were general (59.4%), still significantly lower than would be expected if all task analyses after training were general (χ^2= 37.08, *df*=8, *p*<.00). Again, a comparison between familiar and unfamiliar tasks is of interest given that participants did not have any specific details about how to make Vetkoek or the fictional software program Adgers. Unfamiliar task were expected to show a larger number of general task analyses, yet Chi-square analysis showed that participants created as many general (or specific) task analyses for unfamiliar tasks as for familiar tasks (p=.27). Unfamiliarity with a task did not prevent participants to produce a specific task analysis.

Summary Procedural Knowledge

Participants improved on a number of HTA aspects, even with a brief amount of training. Participants' initial task analysis was shallow (1-2 levels deep) and significantly shallower than task analyses conducted by participants after training, both for the same task and the subsequent task analyses produced. Depth was independent of task familiarity indicating that participants expanded their general representation of the task space. The breadth of participants' task analyses was within recommended boundaries, but included task analyses that were too narrow and too broad.

Participants did not initially state the main goal or used the label *subgoal* or *plan*. Stating the main goal was the only HTA feature that participants improved on to a level not different from maximum. Stating the labels *subgoal* and *plan* increased, but remained at a level significantly below maximum. Similarly, participants mentioned criteria more often and task analyses were more general after training, however, still significantly lower than maximum. Given the lack of information as to the format of HTA, participants mostly resorted to a list style.

Participants identified a larger number of subgoals after they received training compared to participants who analyzed the same tasks before training. However, most subgoals that participants identified were related to lower levels both in their initial task analyses and after training. A potential source of errors was identified in that some task analyses contained an adjusted main goal. Furthermore, novices had problems differentiating between the task to be analyzed and their own task, as indicated by the large number of identified verb-noun pairs related to finding information, learning about, and preparing for the unfamiliar tasks.

Declarative Knowledge of HTA Features

To assess what participants recalled right after instructions and practice, participants were asked to "Please list and briefly describe five main features of Hierarchical Task Analysis".

Unit of Analysis

A segment was defined as a statement containing a feature of HTA as listed by a participant. Typically, participants listed one feature per numbered line on the questionnaire. However, three participants listed more than one feature per numbered line; In this case, the first five features listed were considered in the data analysis (i.e., including more than one per line).

Had all 36 participants listed five features each, there would have been a total of 180 segments. However, the total number of segments (identified features) included in data analysis was only 169. One participant listed only two features, another participant listed only three features, and six features were duplicates of a previously mentioned feature. Thus, the total number of segments identified and included in data analysis was 169 (180 total - 5 blanks - 6 duplicates).

Coding Scheme

Coding categories were informed by both literature (Patrick et al., 2000) as well as data. The main features of HTA were derived from the Introduction to Hierarchical Task Analysis that participants received. If a segment fit one of the category descriptions listed in Table 9.12 it was coded in that category or as *other,* if it did not. Overall agreement between coders was 85% (see Appendix E.2 for reliabilities).

Table 9.12

Coding Scheme for Features of HTA

Features of HTA	Description	Example
Main features		
1. Hierarchical	It's a hierarchy of goals and subgoals	"Create hierarchical task analysis"
2. Main goal	State the high-level goal, overall goal to be achieved	"State high-level goal (overall goal)"; "State task to be analyzed"
3. Subgoals	The sub-elements necessary to carry out the high-level goal	"State subgoals"
4. Plan	State plan (sequence of events) to show when to carry out subgoals	"Have a plan" "Steps involved"
5. Criteria/constraints	The criteria that establish if the task has been properly completed	"Ensure the final goal is satisfied"
Additional features		
6. Purpose of analysis	Determine why you do the task analysis	"State purpose"
7. Boundaries	Set boundaries of the analysis	"Boundaries", "Depth and breadth of analysis".
8. Terminate/stop	Conclude the analysis	"Stop redescription when goal is met", "Stop HTA"
9. Gather data	Collect data	"Collect data"
10. Revise analysis	Revise analysis	Revise analysis
11. Other		

Recalling Main Features of HTA

The first question was whether participants recalled the five defining features of HTA as listed in Table 9.12: *Hierarchical* approach, *goal*, *subgoals*, *plan* (sequence), and *criteria*/constraints against which the task can be considered satisfactory. The combination of these features is particular to HTA and not necessarily part of task analysis in general. No differences between training conditions were expected because all participants received the same information.

Of the 169 features recalled overall, 86 features (50.9%) pertained to the main features of HTA. No participants stated that *hierarchical* was a main feature of HTA. This may indicate that participants did not understand the hierarchical nature of HTA. However, participants may not have mentioned this feature because it may have seemed too obvious, given that the first letter in HTA stands for "hierarchical".

The top three recalled features were: *goal* (75% of participants), *subgoal* (75%), and *plan* (72%). Figure 9.5 shows the percentage of participants (N = 12 per condition) recalling the main features. There was little focus on the feature *criteria* (16.7%). Training conditions did not differ in the number of features recalled (p=.70), but with an average of 59.7% correct, recall of the main features was well below 100% (χ^2= 34.83, df=6, p<.01). Analysis of the residuals (see Appendix E.3, Table E.4) showed that two features were mainly responsible for the effect: The *criteria* feature was mentioned less by all training conditions than would be expected based on maximum accuracy. For the Decision-Action Diagram condition the feature *goal* was also mentioned less than would be expected based on maximum accuracy.

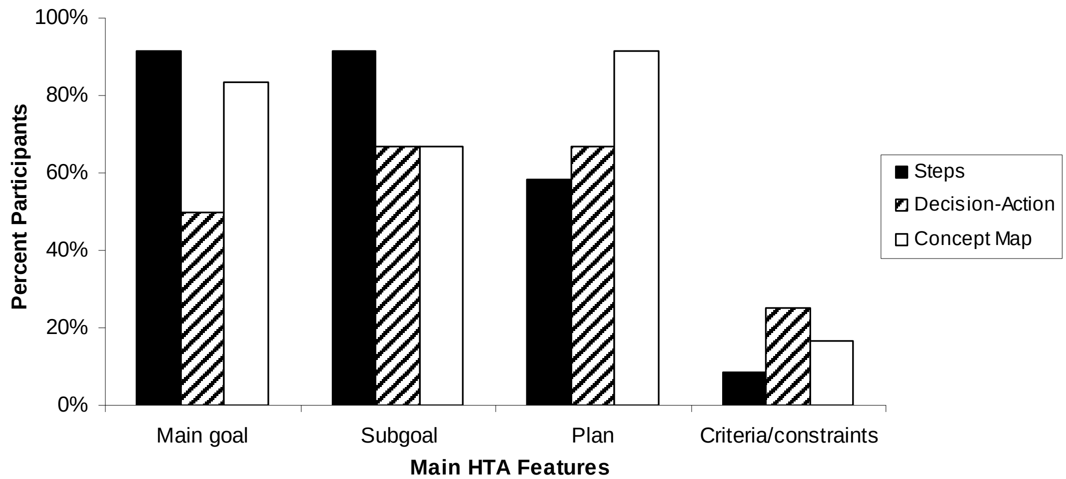

Figure 9.5: Percent of participants (*N* = 12 per training condition) recalling main HTA features.

Additional Features Recalled

Of the 169 features recalled overall, only 86 features (50.9%) pertained to the main features just discussed. Of the 83 answers not accounted for by the main features, 60 answers (35.5% of all answers) could be categorized as additional features that are part of task analysis in general and 23 answers did not fit any category and were coded as *other,* including answers that were unclear as to their meaning. For the coding scheme refer back to Table 9.12.

The most frequently recalled additional feature by all three training conditions was *purpose* of the analysis, accounting for 45.0% of the additional features. Training conditions did not significantly differ in how often they mentioned the *purpose* of the analysis (p=.46); however, it is worthwhile pointing out that all 12 participants in the Decision-Action Diagram condition mentioned the *purpose* because it may be a reason why participants in this training condition mentioned less often the *goal.*

Because of low expected cell counts, no statistical tests were conducted for the remaining features: *gathering data* (23.3% of additional features), *terminating* the analysis (15%), *revising* the analysis (11.7%), and setting the *boundaries* (5%). See Figure 9.6 for the additional features recalled by each training condition.

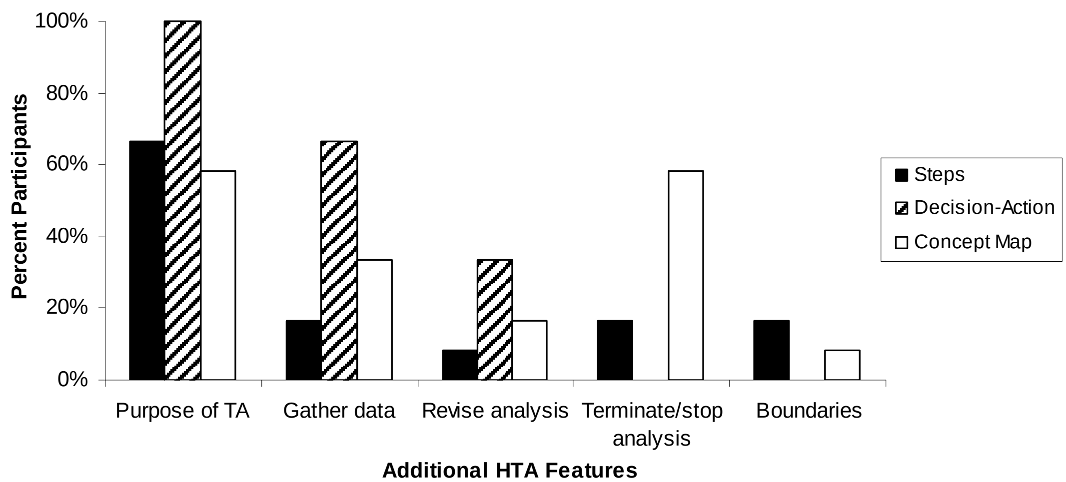

Figure 9.6: Percent of participants recalling additional HTA features by training condition.

Overview of All Features Recalled

From a global perspective, it is also of interest to understand what participants learned about HTA and task analysis in general. Thus, of interest is the pattern of feature recall over all nine categories. Table 9.13 shows the distribution of features frequencies across training conditions.

Table 9.13

All Features Recalled By Training Condition

Feature	**Steps** Count	**D/A** Count	**CM** Count	**Total** (36 max)	**%** Participants	**%** Comments
Purpose	8	12	7	27	75.00	15.98
Main goal	11	6	10	27	75.00	15.98
Subgoals	11	8	8	27	75.00	15.98
Plan	7	8	11	26	72.22	15.38
Gather data	2	8	4	14	38.89	8.28
Terminate/stop analysis	2	0	7	9	25.00	5.33
Revise analysis	1	4	2	7	19.44	4.14
Criteria	1	3	2	6	16.67	3.55
Boundaries of analysis	2	0	1	3	8.33	1.78
Other	8	8	7	23	63.89	13.61
Total	53	57	59	169		100.00

Note. Excludes blanks and duplicate answers. D/A stands for Decision-Action and CM stands for Concept Map.

The features that participants altogether recalled most often were the *purpose* of the task analysis (75% of participants), the *main goal* (75%), the *subgoals* (75%), and closely followed by stating the *plan* (72%). Other recalled features were *gathering data* (39%), *terminating* the analysis (25%), *revising* the analysis (19%), stating *satisfaction criteria* (17%), and determining *boundaries* of the analysis (8%). The Decision-Action Diagram condition did not once mention the *boundaries* of the analysis or *terminating* it. As previously stated, training conditions did not differ in how frequently they recalled the features *purpose* (p=.46), *main goal* (p=.46), *subgoals* (p=.72), or *plan* (p=.61). Because of low expected counts, no analyses were conducted for *gather data.*

Conceptual Confusion

The nature of task analysis is such that it involves two tasks, namely the task of task analysis and the task that is analyzed. Both of these tasks can be thought of having a reason of doing them. During coding it became apparent that participants used the words “goal” and “purpose” somewhat interchangeably when referring to the “task” and the "task analysis". To assess novices' potential confusion, coders recoded segments pertaining to goal and purpose using criteria that were more stringent.

Three categories emerged for the *goal* and the *purpose* (see Table 9.14). Participants mentioned the term *goal* or *purpose* and in their subsequent elaboration, it was clear that they correctly applied these terms (mentioned). Secondly, participants mentioned the terms *goal* and *purpose* without further specifying as to what either term pertained (not further specified). Thirdly, participants used the term goal, but in their elaboration, it became clear that they meant the purpose of the task analysis (purpose–goal of the task analysis). Similarly, participants used the word purpose, but elaboration showed they meant the main goal (main goal – purpose of task). Although this latter confusion did not occur often, participants tended to overuse the word goal in combination with task and task analysis. The finding that novices may over-apply the word *goal* and misalign *goal* and *purpose* with task and task analysis indicates a potential area of confusion that may result in procedural errors when performing the task analysis.

Table 9.14

Raw Frequency of Recalling Goal and Purpose Features By Training Condition

Feature	Steps	D/A	CM	Total	Maximum[a]
Goal - mentioned	5	2	5	12	
Goal - not further specified	6	4	2	12	
Goal - purpose of task	0	0	3	3	
Goal – total	11	6	10	27	36
Purpose - mentioned	2	6	3	11	
Purpose - not further specified	5	3	1	9	
Purpose - goal of TA	1	3	3	7	
Purpose - total	8	12	7	27	36

Note. Excludes blanks and duplicate answers. D/A stands for Decision-Action and CM stands for Concept Map. [a]Maximum per training condition is 12.

Summary – Declarative Knowledge

No participant noted that hierarchical was a main feature of HTA. The top three features of all three training condition were *goal* (75%), *subgoal* (75%), and *plan* (72%). The feature *criteria* (7%) was recalled least by participants. Overall accuracy was only 59%, and mainly due to low recall of the feature *criteria* (all training conditions) and *goal* (only Decision-Action Diagram). However, these main features only captured 50.9% of participants' answers. Five additional feature categories captured 35.5% of the remaining 49.1% of participants' answers with *purpose* of the analysis accounting for most of these additional references (45%).

Considering all of participants' answers, the five most frequently mentioned categories by all training conditions were: *purpose* (75%), *goal* (75%), *subgoal* (75%), *plan* (72%), and *gather* data (36%). Gathering data as a fifth-most frequent feature may reflect that participants included learning-related elements for the unfamiliar tasks. A potentially problematic area was identified as delineating goal from purpose. Participants used the word goal to refer to the purpose of the task analysis and used the word purpose when talking about the task.

Strategies and Decision Factors

In this experiment, participants illustrated procedural knowledge by completing the task analyses and recalled the declarative knowledge they acquired from the instructions. The task analysis questionnaire participants completed at the end of the experiment also prompted participants to share their understanding of HTA concepts. An analysis and discussion follows about how participants identified goals and subgoals and how they decided on the breadth and depth of the analysis.

Unit of Analysis

A segment was a decision factor or reason for identifying goals and subgoals or deciding on the depth or the breadth of the analysis in response to the questions "How did you identify the goals and subgoals?", "How did you decide on the breadth of the analysis, that is, where to start and where to end the task?", and "How did you decide on the depth of the analysis, that is, to which level to analyze to?". A segment was also a definition. Two coders first identified and segmented participants' responses before coding them.

Coding Scheme

The same coding scheme was applied to all three questions (see Table 9.15 and Appendix E.6) and based on patterns in the data. Two general dimensions emerged. Participants either answered by providing a definition ("a goal is..", "The starting point was..") or describing a process (action-oriented). Subcategories for process-based answers emerged as to whether the reference point was a person, a task, or something else (e.g., focused on the action itself). Coders' agreement on the highest behavior category was 97% (subgoals/goals), 90% (breadth decision factors), and 94% (depth decision factors). For reliabilities, see Appendix E.2.

Table 9.15

Coding Scheme for Identifying Goals and Subgoals and Deciding on Breadth and Depth of the Task Analysis

Code	Description	Example
1: Definition-based	Answer describes or focuses on the definition of a concept, point, or circumstance	- *A goal is.. a subgoal is..* - *The starting point was..* - *from.. to..* - *I ended when the task was completed*
2: Process-based	Answer describes or focuses on an action	
	a) Reference point is a person (person factor)	- *based on my knowledge* - *assumed common knowledge* - *fatigue* - *familiarity* - *how I would do it*
	b) Reference point is the task	- *Task complexity* - *Task requires a lot of steps*
	c) Reference point is anything other than the person or the task	- *Thought of simplest way to do it* - *Thought about it from the beginning to the end* - *I tried to be detailed*
3: Other	Didn't do it. No answer	Didn't do it. No answer

How Participants Identified Goals and Subgoals

Coders identified and coded 65 segments related to how participants stated identifying goals and subgoals. Participants mentioned in similar proportions using a definition to identify goals and subgoals (51% of the responses) or an actual process of identifying goals and subgoals (44.6% of the responses). The remaining answers did not fit either category. Training conditions did not differ in the number of definition-related comments (p=.53) or process-related comments (p=.97).

Definitions of *goal* included ”basically the task”, “pretty much given”, “the big picture”, “the main part”, “the main objectives”, and “final product”. One participant did note, however, that the “goal is the main reason for completing the task”, suggesting that the main goal is different from the task of, for example, making a peanut butter jelly sandwich. *Subgoals* then “were the things needed to meet those goal”, and whereas some participants stated something similar in that “each step was a subgoal” other participants thought subgoals “were the elements which were necessary to get the goal, however not broken down into steps like the plan” and “open to my interpretation”.

The general process or strategy of identifying goals and subgoals included “asking questions about the topic”, “determining logical order of event”, or “considered other issues that may arise”, “worked my way from top – down”, choosing “based on what I thought was most important”, or “took a broad plan and split them into simpler tasks”. Comments also related to thinking about the steps, for example, “I knew what my task was so I broke it down step by step” or “I first thought of the necessary steps, then picked out the sub-goals”.

Decision Factors for Determining the Breadth of the Analysis

A total of 60 segments were identified and coded for decision factors that participants stated in response to the question “How did you decide on the <u>depth</u> of the analysis, that is, to which level to analyze to?”. Similar to the previous question, about half of the participants (46.7%) responded by providing a definition and about an equal amount (45.0%) of the participants responded with process-based comments.

A significant effect between training conditions was found both for definition-related factors (χ^2= 7.79, *df*=2, *p*=.02) and process-related factors (χ^2= 6.22, *df*=2,

p=.04). Residual analyses showed that participants in the Concept Map condition were mostly responsible by mentioning fewer process-based factors and more definition-based factors, and participants in the Decision-Action Diagram condition contributed by making fewer definition-based comments than would be expected given all the definition-based comments (see Table 9.16).

Table 9.16

Decision Factors (Raw Scores) For Determining Task Analysis Breadth

Decision Factor	Steps	Decision-Action	Concept Map	Total
Definition-based	10	3	15	28
Process-based	11	13	3	27
Other	1	1	3	5
Overall Total	22	17	21	60

Participants' definitions related to the breadth of the analysis focused on the starting and the ending point. Definitions of a start point included "The start of the task was the first step.", "I generally started with whatever step would begin the actual process", "The breadth started with the biggest question", "I typically started with the gathering of all relevant information", "whatever seemed logically correct as to a beginning". The ending point was "when the tasks were completed", "when the goal was met", or participants "decided not to make it too long". Participants also considered task boundaries when determining the breadth, for example, "Also in certain ones, such as 'making breakfast' I stopped before another task would have occurred (prompt was: making breakfast not making and eating)", "specifically it was to ARRANGE the meeting. So it was arranged. Not in participating in it".

For process-based decision factors, participants mentioned person factors such as using their own knowledge ("I approached the analysis based on my own understanding”), their familiarity with the task (“most of the goals I based on familiarity, those started later in the process”, “kept things very general for more unfamiliar tasks”), or “visualizing myself writing this analysis for another person”. A task–related factor was coded when a participant said “[I] kept things very general from more complex tasks”. Other process-based factors included “I tried to be as specific as possible”, “had a node for failure and a node for success”, and “kept the time limit in mind”.

Decision Factors for Determining Analysis Depth

Participants stated 48 decision factors for determining the depth of the analysis. The lower overall number compared to decision factors related to goals and subgoals and breadth of the analysis is probably due to the absence of any definitions. Most decision factors for determining the depth of the analysis (89.6%) were process-based, and 10.4% were other.

As was seen with the decision factors related to breadth, the decision factors related to depth of the analysis included person factors. Participants stated that the depth of the analysis was influenced by their own knowledge to either increase depth (“by my knowledge of the subject, the more I knew the greater the detail.”) or decrease it (“Some things seemed like common knowledge, so I refrained from writing them down”). Participants also stated considering another person’s knowledge when determining the depth of their analysis (“The depth was only as much detail I figured a common 12 year old would know”, “so that a person with very limited knowledge would probably be able to complete the task.”). Lastly, the depth of participants’ tasks analysis was influenced by their familiarity with the task and their level of fatigue.

Task-related factors that influenced participants' depth of the analysis included being more general for complex tasks and "The more complex the task, the less detail I would use per step". Other process-based decision factors are "I just tried to cover enough to eliminate any reasonable ambiguities", "I just tried to think of some common problems or speed bumps that would be associated with the goal at hand", "went as shallow as I could and still make my case clear", and "the time limit". One participant stayed "as detailed as possible" whereas another participant "stayed very broad - if too many details are discussed, the analysis could go on forever". Participants thought of all the different possibilities, increase depth when steps were not self-explanatory, and "tried to keep the goal in mind and only to include steps that contribute to that goal".

Summary Decision Factors

Novices used two main strategies to guide identification of goals and subgoals as well as determining breadth and depth of the analysis: use a definition or a process. Definitions were used to identify goals and subgoals as well as the breadth of the analysis, but were not mentioned for determining the depth. Process-based decision factors included person factors (e.g., prior knowledge, task familiarity), task factors (e.g., task complexity), and other, such as asking questions, determining logical order, being specific, being shallow, considering problems, eliminating ambiguities. The same factors were mentioned by different participants as a reason both for a narrow or broad task analysis.

CHAPTER 10: STUDY 2 - DISCUSSION

Literature on training HTA is limited, but indicates that learning HTA is not trivial, requiring time and practice. Some errors of HTA have emerged, such as task analyses that were too narrow and focusing on sub-ordinate goals (Stanton & Young, 1999; Patrick et al., 2000). Conclusions about the relative benefits of declarative and procedural training, however, remain unclear because of experimental design, limited published information, use of non-orthogonal criteria to assess novice performance, few details about training materials, and specification of what “too narrow” constitutes.

The goal of this study was to explore and capture novices’ untrained and trained performance in task analysis by assessing declarative and procedural knowledge. Did novices generate the required procedural knowledge based on brief, declarative, whole-task training, and did this differ as a function of training condition? What were novices’ misconceptions and errors? .

Procedural knowledge was assessed by qualitative data analysis of the task analyses that novices produced. Coding criteria for the task analyses were based on main features of HTA (Shepherd, 2001) and informed by categories used in literature (Patrick et al., 2000). A recall test at the end of the experiment assessed declarative knowledge, and a questionnaire prompted participants to state what influenced their identification of goals, subgoals, and decisions on depth and breadth of the analysis.

Novices’ Untrained Performance

Without instruction, novices provided a very brief, basic task analysis. These task analyses were within the range of suggested breadth of three to eight elements, yet rather shallow and not really a hierarchy (one or two levels deep). The main goal and criteria, two main features of HTA, were only mentioned once. Novices' initial task analyses were mostly specific (72%), for example, to a technology used. Participants identified more lower-level subgoals than main level ones, and even as a group did not cover all the main level subgoals as stated in the master task analyses. Given no information as to the format of a task analysis, participants mostly chose a list-style, but also included flowcharts and pictures. No data of untrained novice performance are available, and these data provided a baseline to compare trained performance against in this study.

What Did Novices Learn?

Hierarchy Dimensions

Breadth of the task analysis. The breadth of task analyses did not differ significantly for all tasks, that is, before and after training. The average breadth and majority of task analyses was within the suggested range of at least three to eight elements. However, without further instructions as to the desired breadth participants also created task analyses that were too narrow or too broad. Questionnaire data showed that participants used both definition and process-based factors to decide on the breadth of the analysis, that is, where to start and where to end. The start included definitions such as "the first step", "gathering data", or "logic", with the end being defined as "the task was complete". However, participants also determined the breadth by using their prior knowledge, task familiarity, and other factors such as trying to be specific or considering the time limit. These data suggest that further instruction is needed .

Depth of the task analysis. Participants' trained task analyses of the initial task were significantly deeper than participants' untrained task analyses, a change that held for all five task analyses completed after training. Depth did not differ as a function of task familiarity, suggesting that participants developed an idea of how deep a task analysis should be, expanding the depth of their task space from one and two up to four levels. This is success in that it indicates that participants demonstrated that a task needs to be analyzed to different levels. However, this finding should be interpreted cautiously. No participant stated that *hierarchical* was a main feature of HTA, and there were participants who created task analyses after training that were still only one level deep.

Questionnaire data showed that most participants used process-related factors to decide on the breadth, including prior knowledge, familiarity, fatigue, task complexity, and other factors such as wanting to be as shallow or succinct as possible, or eliminate ambiguities. The same factors were referred to as a reason to increase <u>and</u> decrease the depth of the analysis.

The goal of this study was to determine the hierarchical dimensions independently and prior to addressing the questions of equivalent redescription and other requirements of HTA. However, as a prerequisite to redescription, this study's data suggest that most of novices do expand their task space but that more training is needed.

Goal

Stating the main goal is an important feature of HTA. Without stating the main goal it is not clear what task is being analyzed and confusion can result. Participants in this study clearly demonstrated that they recognized the importance of this feature, both in their task analysis products and recall test.

Nevertheless, there were errors and misconceptions. Participants not only stated the main goal in their task analysis but also adjusted it. Thus, stating the goal is closely related to questions of "how precisely do I need to state the main goal?" and "can I make adjustments?" Training could address these questions. Declarative knowledge assessment showed that participants recognized the importance of goal and purpose, but also confused these two terms and how they relate to the task and the task analysis. The word *goal* is strongly tied to the task, whereas the word *purpose* is typically used to refer to task analysis (Wickens, Lee, Liu, Becker, 2004), which the initial instructions did not convey clearly or effectively, a signal for the need of more specific instructions.

Subgoals

Participants identified a larger number of subgoals of the initial tasks when trained which illustrates that novices recognized that identifying subgoals is an important feature of HTA. This finding is corroborated by 75% of participants mentioning subgoals as a main feature of HTA. Consistent with previous research (Patrick et al., 2000), though, most identified subgoals were lower level (79%). The emphasis on lower level subgoals was independent of training or task familiarity, the latter of which is surprising given that participants did not have specific details available for unfamiliar tasks. Participants identified more extra subgoals for unfamiliar tasks, and these were mostly related to learning about or preparing for the task, which suggests that participants had problem separating their task of analyzing a task from performing the task.

Novices, again, used definitions and process based factors to identify goals and subgoals, including asking questions and determine the order. Lastly, participants appeared to have problems separate verb-noun pairs into small packages, an observation that could be further analyzed. Novices tended to string verb-noun pairs together, for example, in a plan style such as a paragraph of text but also for list styles.

Plan

Novices showed that they recognized the importance of the plan to HTA, however, mostly in the declarative knowledge assessment. Without further instructions as to the format of HTA, participants initially showed a variety of choices (including pictures and gestures), but mostly used list styles and flowcharts. Only few participants chose a hierarchy, which is in line with Patrick et al. (2000) who found that participants had problems using a hierarchy even when explicitly told to do so. Plan styles such as a paragraph of text suggest that participants had problems dissociating subgoals from their sequence, which may also inform training design.

Criteria

Mentioning criteria significantly increased from nothing and was stable at 65% over all 5 trained tasks, however, still significantly below maximum. In recall test, participants did not consider this as a main feature of HTA (7% of all features mentioned) which suggests that this feature needs more emphasis and elaboration in training.

Versatility

Patrick et al. (2000) found that novices' task analyses were rather specific. The same was found in this study. The number of general task analyses did not significantly increase compared to untrained performance. Although the number of general task analyses increased to 59% across all trained tasks, this number is still significantly below maximum. Participants even created specific task analyses for unfamiliar tasks, possibly revealing a thought pattern.

Did Training Matter?

Participants in this study received one of three types of instructional materials to illustrate the concepts of Hierarchical Task Analysis, each emphasizing a different aspect of this task analysis method. The data did not provide much support for a differential effect of the spatial diagrams on procedural knowledge as differences between training groups were minimal. This may be due to the limited amount of training in both duration and content. A future study with more elaborated training material or longer training duration could investigate whether spatial diagrams support and differentially affect knowledge acquisition.

Skill Components as Informed by Novices

Data gathered in this study provide systematically collected baseline data to the collection of knowledge about functional task analysis. Furthermore, the categories for evaluating novice performance on HTA brought forward by Patrick et al. (2000) were supported and amended with different operational definitions that allowed assessment of performance of HTA features independently of each other. Findings from this study suggest the following skill components of functional task analysis:

- **Identify subgoals**
    - select level of analysis
    - define subgoal
    - identify subgoal
    - delineate subgoal from other subgoals
    - consider prior knowledge
    - consider task factors
    - consider time constraints

- **Create hierarchy**
    - set task structure dimensions
    - expand breadth
    - reduce breadth
    - expand depth
    - reduce depth

- **Determine task boundaries**
    - Breadth of analysis
        - define breadth of task analysis
        - determine breadth of task analysis
        - recall minimum breadth
        - recall maximum breadth
        - determine if breadth is appropriate

    - Depth of analysis
        - define depth of task analysis
        - determine depth of task analysis

- **Determine task goal**
    - define goal of the task
    - define purpose of the task analysis
    - differentiate goal and purpose
    - delineate task to be analyzed from task of task analysis
    - identify goal
    - delineate task goal from other (similar) task goals

- **Versatility**
    - consider different ways to complete a task

- **Determine Plan**
    - choose an HTA format
    - follow HTA format
    - adjust HTA format
    - determine sequence
    - separate sequence from content

- **Determine Criteria**
    - identify criteria
    - state criteria

Implications for Training Design

Participants did demonstrate knowledge of some features of HTA, but did not spontaneously develop all of the procedural knowledge required with this brief training. Reading an introductory chapter is not sufficient to apply the method right after training. Further training is needed. Trainers of HTA can also benefit, for example, from the knowledge and be mindful that novices may be confused about the differences between task goal and the purpose of the task analysis, that they may want to adjust the goal. The skill components identified can inform the design of training in terms of specific objectives, once they are validated. Findings suggest two routes for training: ensure appropriateness and usefulness of definitions and review how novices' prior knowledge may be beneficial to or hinder conducting task analysis.

CHAPTER 11: GENERAL DISCUSSION

The goal of this dissertation was to advance knowledge of functional task analysis by taking a skill acquisition approach to demystify the "art" of task analysis and identify underlying skill components. Literature indicated the need to train the skill of functional task analysis (Stanton & Young, 1999), showing a lack of precise definition and sufficiently specified knowledge (e.g., Shepherd, 2001). The next step in developing training material from an instructional design perspective is a task analysis (or principled skill decomposition) of the skill under investigation (e.g., van Merriënboer, 1997). The two studies conducted for this dissertation explored the skill of functional task analysis following the first step of the expert-novice approach outlined by (Ericsson & Smith, 1991). A master task analysis was created for each of the six tasks used in the studies in an effort to standardize and compare participants' task analyses.

Professionals with at least two years of experience with conducting task analysis made up the sample in the first study. The goals of study 1 were to capture and characterize professionals' task analysis products and process. *Novices* at conducting task analysis participated in the second study, and the goal was to capture and characterize novices' untrained performance and assess the procedural and declarative knowledge novices acquired after brief training of HTA.

In this chapter, main findings of both groups are discussed. Groups are compared in terms of similarities and differences in patterns and not in terms of specific numbers, given that the studies were not designed to directly compare performance. Future research design should focus on direct quantitative comparisons.

Pattern Similarities and Differences

Hierarchy Dimensions

Novices' average breadth was within the specified range of three to eight elements and did not differ significantly for all six tasks. After training, the range of the breadth increased**.** Professionals' average breadth was also with parameters, and there was a difference between tasks but not as a function of task familiarity. Although the average breadth and the majority of both groups' task analyses was within the suggested range, both novices and professionals produced task analyses they were below or above those breadth recommendations.

Novices' initial task analyses were flat with an average depth of 1.2 levels and increased with minimal training to 2.1 levels. This increase was stable and independent of task familiarity. This illustrates that novices increased the boundaries of their task representation, the foundation on which topics such as equivalence of redescription can be discussed. However, novices still created task analysis of only one level after training. Although professionals created task analyses with an average depth of 2.3 levels while thinking aloud, some professionals' task analyses also were only one level deep.

These numbers provide a general sense of the hierarchy dimensions in breadth and depth. Both novices and professionals created task analyses that were similar in dimensions, and both groups showed similar deviations (one level deep, too narrow, and too broad). Future research could address whether these deviations have associated drawback or benefits. Future research could also address whether there is a preferable or optimal breadth-depth ratio.

Subgoals

Of interest was whether participants included high-level subgoals, and if novices focused on lower level subgoals as found in previous studies (Patrick et al., 2000). Data analysis showed that novices focused mostly on lower level subgoals (79% after training). Similarly, professionals also focused on lower subgoals (90%), irrespective of task familiarity. This suggests that given the 15-minute timeframe, novices' performance may be to be expected. However, given that revision is part of task analysis, further investigation is needed.

As to what subgoals participants included and excluded in the task analyses, both professional and novice participants tended to included subgoals such as learning about unfamiliar tasks, except for one participant who concluded that this would not be part of the task analysis. It is unclear if it is a strategy or potential pitfall that task analysts allow their role of a task performer to inform the resulting task analysis product. This is a direction for future research, given that task analysts create drafts by drawing on existing documents and their prior knowledge. Another potential strategy for identifying subgoals is the use of symmetrical subgoals. Future studies could investigate whether task analysts do indeed use subgoals such as "open jar" as a cue to include "close jar" and vice versa.

A challenge for novices to overcome and direction for future investigation is how professionals and novices differ in their "unit of analysis". Coding of task analysis products indicated that novices tended to chunk verb-noun pairs, for example by choosing a paragraph of text style but also when using lists styles. Professionals' task analyses tended to have smaller chunks that included generally only one verb-noun pair. Future analyses could investigate this further.

Versatility

Novices' initial task analyses were mostly specific (83%), which decreased to 42%. Professionals' task analyses showed a similar pattern with 44% of task analyses being specific. Professionals' think-aloud data showed that some participants purposefully constrained their problem space or modeled a technology, whereas others focused on a specific person and situation because of the nature of their work (Occupational Therapist). Novices and experienced task analysts arrived at the same overall level of versatility; however, further investigation is needed to assess whether novices chose their approach on purpose or used it as a default.

Process of Identifying Subgoals

Much has been written about how goals differ from tasks, actions, and so forth (e.g., Endsley et al., 2003), yet it is not clearly described how to actually identify the elements of a task. How did participants identify subgoals and what helped them? Data from study 1 may speak to this matter. Professionals did not clearly favor a breadth-first or depth-first approach across all tasks, but used questions and assumptions to guide the task analysis process. Questions were mostly related to *what*. Data analyses indicated that questions about *what* were directed to understand the task space, identify objects in that space, determine procedure, specific requirements, check specific task aspects, and search the task space. The few questions about *why* revolved around questioning the given task description and determining whether a different task description might be more appropriate. Novices also indicated using questions; however, no data were collected as to the nature of these questions. Future research could assess the similarities and differences in questions between novice and experienced task analysts and assess whether the nature of the questions changes when professionals converse with the subject matter expert and revise the task analysis.

Also, participants moved around elements within the hierarchy and searched for the right word, indicating a dynamic aspect to this phase of task analysis. This suggests that there may be a cycle of questions that guides the task analyst, a reasoning chain that involves a certain sequence of questions and answers. For example, the first questions may be *what* and *how* to obtain an understanding of the task as it is done in its very specific procedural details (e.g., "light the stove"). This in turn may provide the basis for finding super-ordinate inferences such as *why* and defining criteria by asking *when*. Questions about *where* and *who* might be asked at any given points in time.

Theoretical Significance

The findings of the two studies conducted for this dissertation suggest the skill components of functional task analysis as outlined in chapters 6 and 9. Some of the components overlap (e.g., identify subgoal), and some components are unique to each group. This difference could be an artifact of the difference in study design and data analysis or suggest that groups at different ends of the experience spectrum are concerned with different challenges (e.g., novice having to expand the task depth).

More generally, data from this dissertation indicated that task analysts extract, create, and apply task structures but differ in their emphasis. This difference in emphasis is important for understanding and furthering the definition of the underlying expertise. Creating and applying task structures can be linked to two strategies suggested by Shepherd (2001). One strategy is to conduct a task analysis and applies when the task analyst is not familiar with the task. The second strategy applies to a task analyst who worked in a particular industry for a number of years and acquired familiarity with the work and the associated issues. The experienced task analyst shortcuts the process of creating a task analysis product and focuses directly on fulfilling the task analysis purpose, for example, locating major problems. This second strategy indicates that a task analyst uses prior knowledge, experience gleaned from previous task analysis experiences, that is, the task structure and related findings. Drawing on existing knowledge (in this case task structures) based on the specific task analysis demands is consistent with the assertion that superior performance is associated with pattern-based retrieval from memory (Ericsson & Lehmann, 1996).

Research has shown that expertise is often tied to a particular domain, for example, chess, computer programming, or physics (Ericsson & Lehmann, 1996). It is commonly accepted that a task analyst is experienced in task analysis but a domain novice of the task to be analyzed. Yet, a task analyst also acquires familiarity with a domain. Shepherd (2001) suggested that task analysts recognize and exploit task similarities between different domains, stating that the task of *monitoring* exists in an automated industrial plant or in nursing in an intensive care unit. Both require the user to know parameters to monitor, know target values, require continuous monitoring, and require reliability. If the task analyst recognizes these task structure similarities, it helps alert the analyst to main issues.

This suggests that the domain of task analysts' expertise is not tied to a specific content area (e.g., military or process control) but involves tasks that share a common structure across content areas. The implication is that task analysts become experienced at perceiving and thinking in terms of task structures and task variables. Findings in the current study that speak to that matter are two of the eight professional task analysts who noted and commented on the similarity of tasks. A future study could focus on the perception of task structure similarities by professionals and novices.

Equivalence and Inter-Analyst Reliability

Reliability is an important aspect of a method. The quest to determine the reliability, validity, efficiency, and effective of a task analysis is still ongoing, and it has been suggested to understand qualities of poor and good task analyses instead (Hoffman & Militello, 2009). Study 1 professionals used different approaches, but tended to clearly identify and separate individual verb-noun pairs rather than placing them all together. List-style task analyses showed a clear hierarchical structure with at least two sub-bullets to a single bullet. However, there were inter- and intra-individual differences. Using versatility as an example, one participant created only specific task analyses, another participant created only general ones, and the remaining analysts were located between these two extremes.

The initial intent of this dissertation was to aid the development of reliability measures for functional task analysis. However, maybe the way to inter-analyst reliability is not to ask "how can we measure reliability between and within task analysts?", but instead focus on what can be done to improve it. Defining small areas that task analysts can discuss and agree upon will reduce ambiguity, such as whether there is a task symmetry and if a task analyst should consider and check the "closing jar" question after having "opened" it? If consensus can be reached, then discussion can continue by identifying what these symmetrical subgoals are for different tasks, and when they should be included. Continuing to define the problem space of task analysis in this manner should help improve inter-analyst reliability as well as training by providing guidelines.

Criteria for Evaluating Task Analysis Products

Currently no accepted measures for evaluating task analysis products exist, and studies have been vague in their description of how the quality of task analysis products was assessed (e.g., Stanton & Young, 1999). Patrick et al. (2000) brought forward criteria to evaluate HTA such as: hierarchical, equivalence, logical decomposition, and versatility. Given novices' poor performance in these studies (Stanton & Young; Patrick et al.), this dissertation focused on general characteristics and creating master task analyses for comparable assessment. Some of the categories suggested by Patrick et al. were confirmed (e.g., versatility) and similar errors found (expressing subgoals as actions rather than as goals). In addition, the general dimension of a hierarchy (breadth and depth) is suggested as a criterion to understand task analysis products.

Practical Implications

Clarifying Misconceptions

Declarative knowledge tests showed that novices used and confused the words "goal of the task" and the "purpose of the task analysis", both important concepts of task analysis. Training could start by delineating the two ideas. Then, as a second step, training could incorporate how the purpose of the task analysis informs the process of task analysis itself. Current literature on training TA does not emphasize enough how the purpose of the analysis is related to and informs the actual process.

Teaching Task Analysis

The task analysis products of both professionals and novices can serve as examples of the "*do's and do not's*", for example, to illustrate errors such as not mentioning the main goal. Another error that surfaced in this study is adjusting the main goal. Reasons for and against adjusting the main goal could be discussed along with implications, that is, how is the analysis affected?

Professionals' task analyses can also be used as examples to illustrate the range of task analyses, depending on their purpose. A teacher could use the task analyst space to explain to students the range of applicability of a task analysis. Also, the questions that participants asked can serve as a tool to help students develop a structured process.

Task Representation

The task analysis products that participants created in the context of this dissertation represent a combined understanding of the tasks that were analyzed. This understanding can be important for practitioners in two ways. The task analysis products created by professionals are informative for professionals as to how their colleagues view and represent the same task. The task analysis products created by novices provided insight into their underlying task representation. As such, task analysis may be viewed as a reflection of a task representation and knowledge derived from these products may be directly applicable by practitioners in their system design or redesign.

Contributions

This study systematically investigated novices and experienced task analysts' performance on the same set of tasks, and the data and findings contribute to the knowledge about the skill of functional task analysis. The master task analyses created to assess the task analyses provide a source and position for discussion of a particular task to advance consensus in the field about what should be included in a task, what should be left out and why, or under what conditions. Most importantly, the present research provided a model for considering task analysis not as an art but overall as a skill.

APPENDIX A: TASKS AND MASTER TASK ANALYSES

A.1 Stimulus Material

Making a peanut-butter jelly sandwich

Making breakfast

Making Vetkoek (a South African main dish)

Making a phone call

Arranging a meeting

Sharing pictures using Adgers

(a communication software)

A.2 Master Task Analyses

Master Task Analysis **0: Making Peanut Butter Jelly Sandwich** 30 March 2010

Minimum goals

1. **Get recipe**
   - **1.1. Find recipe**
   - 1.1.1. Determine procedure
   - 1.1.2. Determine ingredients
   - **1.2. Adjust recipe**
   - 1.2.1. Search available ingredients
   - 1.2.2. Adjust # servings
   - 1.2.3. Adjust ingredients
2. **Follow recipe**
   - **2.1. Get materials**
     - 2.1.1. Gather cooking apparatus
     - 2.1.2. Gather pots and pans
     - 2.1.3. Gather utensils
       - 2.1.3.1. Get knife
       - 2.1.3.2. Get spoon
       - 2.1.3.3. Get plate (to work on)
     - 2.1.4. Gather ingredients
       - 2.1.4.1. Get peanut butter
       - 2.1.4.2. Get butter
       - 2.1.4.3. Get jelly
       - 2.1.4.4. Get bread
   - ***2.2.* Prepare ingredients**
     - 2.2.1. Warm or cool ingredients
     - 2.2.2. Slice or cut ingredients
       - 2.2.2.1. Slice bread (one slice from loaf)
       - 2.2.2.2. Cut bread (in half etc.)
     - 2.2.3. Measure ingredients
     - 2.2.4. Mix ingredients
     - 2.2.5. Assemble sandwich
       - 2.2.5.1. position first slice
       - 2.2.5.2. put slices together
     - 2.2.6. Combine ingredients
       - 2.2.6.1. Put butter on bread
         - 2.2.6.1.1. Open butter dish
         - 2.2.6.1.2. Cut butter
         - 2.2.6.1.3. Smear butter on bread
       - 2.2.6.2. Put peanut butter on bread
         - 2.2.6.2.1. Open peanut butter jar
         - 2.2.6.2.2. Scoop out peanut butter
         - 2.2.6.2.3. Smear peanut butter on bread
       - 2.2.6.3. Put jelly on bread
         - 2.2.6.3.1. Open jelly jar
         - 2.2.6.3.2. Scoop out jelly
         - 2.2.6.3.3. Smear jelly on bread
       - 2.2.6.4. Select utensil
       - 2.2.6.5. Clean utensil
     - 2.2.7. Ensure working area is clean
     - 2.2.8. Season to taste
   - **2.3. Prepare technology**
     - 2.3.1. Determine method of preparation (e.g., cold vs. warm, stove, oven, microwave)
     - 2.3.2. Power-up technology
       - 2.3.2.1. provide power (plug in)
       - 2.3.2.2. preheat
   - **2.4. Prepare food** (e.g., cook, brew, steam)
     - 2.4.1. Input ingredients to medium
     - 2.4.2. Adjust temperature (heat/cool)
     - 2.4.3. Monitor time
     - 2.4.4. Check for doneness
     - 2.4.5. Remove ingredients from medium

Additional goals

3. **Serve**
   - 3.1. Decide on details
   - 3.2. Get serving materials (e.g., cutlery, dish, plates)
   - 3.3. Plate/pour dish
   - 3.4. Add toppings (e.g., pickles, sauces, sugar)
   - 3.5. Hand over dish
4. **Enjoy dish (eat/drink)**
5. **Wrap-up**
   - 5.1. Turn-off equipment
   - 5.2. Store away items
   - 5.3. Clean (wipe, scrub, rinse)

Minimum goals

1. **Determine what to make**
    - 1.1. Browse what is available
    - 1.2. Choose breakfast items
    - **1.3. Find recipe**
        - 1.3.1. Determine procedure
            - 1.3.1.1.Search food recipe
            - 1.3.1.2.Search drink recipe
        - 1.3.2. Determine ingredients
    - **1.4. Adjust order**
        - 1.4.1. Search available ingredients
        - 1.4.2. Adjust # servings
        - 1.4.3. Adjust ingredients

2. **Prepare food**
    - **2.1. Get materials**
        - 2.1.1. Gather cooking apparatus
        - 2.1.2. Gather pots and pans
        - 2.1.3. Gather utensils
        - 2.1.4. Gather ingredients
    - **2.2. Prepare ingredients**
        - 2.2.1. Get ingredients out
        - 2.2.2. Warm or cool ingredients
        - 2.2.3. Slice or cut ingredients
        - 2.2.4. Measure ingredients
        - 2.2.5. Mix ingredients
        - 2.2.6. Combine ingredients
        - 2.2.7. Season to taste
    - **2.3. Prepare technology**
        - 2.3.1. Determine method of preparation (e.g., cold vs. warm, stove, oven, microwave)
        - 2.3.2. Power-up technology
            - 2.3.2.1. provide power (plug in)
            - 2.3.2.2. preheat
    - **2.4. Prepare food** (e.g., cook, brew, steam)
        - 2.4.1. Input ingredients to medium
        - 2.4.2. Adjust temperature (heat/cool)
        - 2.4.3. Monitor time
        - 2.4.4. Check for doneness
        - 2.4.5. Remove ingredients from medium

3. **Prepare beverage**
    - **3.1. Get materials**
        - 3.1.1. Gather cooking apparatus
        - 3.1.2. Gather pots and pans
        - 3.1.3. Gather utensils
        - 3.1.4. Gather ingredients
    - **3.2. Prepare ingredients**
        - 3.2.1. Get ingredients out
        - 3.2.2. Warm or cool ingredients
        - 3.2.3. Slice or cut ingredients
        - 3.2.4. Measure ingredients
        - 3.2.5. Mix ingredients
        - 3.2.6. Combine ingredients
        - 3.2.7. Season to taste
    - **3.3. Prepare technology**
        - 3.3.1. Determine method of preparation (e.g., cold vs. warm, stove, oven, microwave)
        - 3.3.2. Power-up technology
            - 3.3.2.1. provide power (plug in)
            - 3.3.2.2. preheat

- **3.4. Prepare beverage** (e.g., cook, brew, steam)
    - 3.4.1. Input ingredients to medium
    - 3.4.2. Adjust temperature (heat/cool)
    - 3.4.3. Monitor time
    - 3.4.4. Check for doneness
    - 3.4.5. Remove ingredients from medium

Additional goals

4. **Serve**
    - 4.1. Decide on details
    - 4.2. Get serving materials (e.g., cutlery, dish, plates)
    - 4.3. Plate/pour dish
    - 4.4. Add toppings (e.g., pickles, sauces, sugar)
    - 4.5. Hand over dish
5. **Enjoy dish (eat/drink)**
6. **Wrap-up**
    - 6.1. Turn-off equipment
    - 6.2. Store away items
    - 6.3. Clean (wipe, scrub, rinse)

Minimum goals

1. **Get recipe/order**
   - 1.1. Find recipe
   - 1.1.1. Determine procedure
   - 1.1.2. Determine ingredients
   - 1.2. Adjust recipe
   - 1.2.1. Search available ingredients
   - 1.2.2. Adjust # servings
   - 1.2.3. Adjust ingredients
2. **Follow recipe**
   - **2.1. Get materials**
   - 2.1.1. Gather cooking apparatus
   - 2.1.2. Gather pots and pans
   - 2.1.3. Gather utensils
   - 2.1.4. Gather ingredients
   - ***2.2.* Prepare ingredients**
   - 2.2.1. Get ingredients out
   - 2.2.2. Warm or cool ingredients
   - 2.2.3. Slice or cut ingredients
   - 2.2.4. Measure ingredients
   - 2.2.5. Mix ingredients
   - 2.2.6. Combine ingredients
   - 2.2.7. Season to taste
   - **2.3. Prepare technology**
   - 2.3.1. Determine method of preparation (e.g., cold vs. warm, stove, oven, microwave)
   - 2.3.2. Power-up technology
     - 2.3.2.1.provide power (plug in)
     - 2.3.2.2.preheat
   - **2.4. Prepare food** (e.g., cook, brew, steam)
   - 2.4.1. Input ingredients to medium
   - 2.4.2. Adjust temperature (heat/cool)
   - 2.4.3. Monitor time
   - 2.4.4. Check for doneness
   - 2.4.5. Remove ingredients from medium

Additional goals

3. **Serve**
   - 3.1. Decide on details
   - 3.2. Get serving materials (e.g., cutlery, dish, plates)
   - 3.3. Plate/pour dish
   - 3.4. Add toppings (e.g., pickles, sauces, sugar)
   - 3.5. Hand over dish
4. **Enjoy dish (eat/drink)**
5. **Wrap-up**
   - 5.1. Turn-off equipment
   - 5.2. Store away items
   - 5.3. Clean (wipe, scrub, rinse)

Master Task Analysis | **0: Making a phone call** | 30 March 2010

<u>Minimum goals</u>

1. Determine receiver information
- 1.1. Choose receiver
- 1.2. Find contact information (phone number)
  - 1.2.1. Determine where to search
  - 1.2.2. Search directory
  - 1.2.3. Search notes
  - 1.2.4. Search web
  - 1.2.5. Search speed dial
  - 1.2.6. Search other

2. Find phone
- 2.1. Select phone (e.g., cell phone)
  - 2.1.1. Determine what phones are available (cell, land line)
  - 2.1.2. Determine phone characteristics (free minutes)
  - 2.1.3. Determine conversation preferences
- 2.2. Locate phone

3. Connect
- 3.1. Establish communication with phone
  - 3.1.1. Pick up receiver
  - 3.1.2. Press button
  - 3.1.3. Other
- 3.2. Communicate receiver information
  - 3.2.1. Enter numbers (digit by digit input)
  - 3.2.2. Press shortcut (speed dial)
  - 3.2.3. other
- 3.3. Initiate connection
  - 3.3.1. press button
  - 3.3.2. other
- 3.4. Verify connection
  - 3.4.1. Listen to dial tone
  - 3.4.2. other

<u>Additional goals</u>

4. Communicate
- 4.1. Talk
- 4.2. Listen

5. End call
- 5.1. Choose method of disconnecting (e.g. close lid, button)
- 5.2. Disconnect (Activate disconnection mechanism)
- 5.3. Return phone to resting place
- 5.4. Obtain feedback that connection ended

Master Task Analysis **0: Arrange a meeting** 30 March 2010

Minimum goals

1. **Determine date and time**
    1.1. Select possible dates
    1.2. Select possible times
    1.3. Determine own availability
    1.4. Check availability of attendees
    1.5. Narrow down/adjust date/time
    1.6. Finalize date and time
        1.6.1. Set date
        1.6.2. Set time

2. **Determine attendees**
    2.1. Create list
        2.1.1. Browse people list
        2.1.2. Select people
    2.2. Request attendance
        2.2.1. Send invitation/inform
        2.2.2. Obtain answer
    2.3. Create attendance list

3. **Determine location**
    3.1. Choose location
        3.1.1. Browse locations
        3.1.2. Determine availability of location
        3.1.3. Determine other requirements
    3.2. Reserve location
    3.3. Verify reservation

4. **Determine reason for meeting**
    4.1. Create agenda
    4.2. Verify agenda

5. **Confirm meeting details**
    5.1. create confirmation message
    5.2. select confirmation medium
    5.3. communicate to attendees
        5.3.1. confirm date
        5.3.2. confirm time
        5.3.3. confirm location
        5.3.4. confirm agenda
    5.4. communicate to location
    5.5. communicate to self

Additional goals

6. **Prepare for meeting**
    6.1. Prepare materials
    6.2. Prepare room

7. **Meet**
    7.1. Talk
    7.2. Listen

8. **End meeting**
    8.1. Determine end of the meeting
    8.2. Leave
    8.3. Follow-up

Master Task Analysis **0: Sharing pictures using Adgers (a communication software)** 30 March 2010

Minimum goals

1. Obtain picture
- 1.1. take picture
- 1.2. process picture
- 1.3. print picture
- 1.4. scan picture
- 1.5. save picture
- 1.6. retrieve from digital camera
- 1.7. retrieve from hard drive

2. Determine picture to be shared
- 2.1. Recall what pictures are available
- 2.2. Search pictures
- 2.3. Select picture

3. Determine receiver information
- 3.1. Choose receiver
- 3.2. Find contact information

4. Share picture/Loan picture
- 4.1. Make picture available to receiver
- 4.2. Get confirmation that receiver got picture

5. Connect by using Adgers
- 5.1. Establish communication with Adgers
- 5.2. Communicate receiver information to Adgers
- 5.3. Initiate connection
- 5.4. Verify connection

Additional goals

6. End sharing
- 6.1. Determine end of sharing
- 6.2. Disconnect from Adgers
- 6.3. Return Adgers to resting place
- 6.4. Get picture back from receiver
- 6.5. Get confirmation that received picture back

APPENDIX B: STUDY 1 - MATERIALS

B.1 Recruitment questions

The recruitment questions were as follows:

1. What is your native language?
2. Do you use task analysis in your job?
3. For how many years have you conducted task analysis?
4. In the past year, how many projects have you worked on for which you conducted a task analysis?

B.2 Demographics and Experience Questionnaire

Please answer the following questions. All of your answers will be treated confidentially. Any published document regarding these answers will not identify individuals with their answers. **If there is a question you do not wish to answer, please just leave it blank and go on to the next question.** Thank you in advance for your help.

Demographics and Experience Questionnaire

1. Gender: **Male** ☐$_1$ **Female** ☐$_2$

2. Date of Birth: __ __ / __ __ / __ __ **Age:** _______

3. How would you describe your primary racial group?

☐$_1$ No Primary Group
☐$_2$ White Caucasian
☐$_3$ Black/African American
☐$_4$ Asian
☐$_5$ American Indian/Alaska Native
☐$_6$ Native Hawaiian/Pacific Islander
☐$_7$ Multi-racial
☐$_8$ Other (please specify) ____________________

4. Do you consider yourself Hispanic or Latino?

☐$_1$ Yes
☐$_2$ No

4 a. If "Yes", would you describe yourself:

☐$_1$ Cuban
☐$_2$ Mexican
☐$_3$ Puerto Rican
☐$_4$ Other (please specify) ______________

5. Is English your primary language?

☐$_1$ Yes
☐$_2$ No

5 a. If "No", What is your primary language? ____________________

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6. What is your highest level of education?

☐$_1$ No formal education
☐$_2$ Less than high school graduate
☐$_3$ High school graduate/GED
☐$_4$ Vocational training........................ Major: ______________
☐$_5$ Some college/Associate's degree........................ Major: ______________
☐$_6$ Bachelor's degree (BA, BS)........................ Major: ______________
☐$_7$ Master's degree (or other post-graduate training)........ Major: ______________
☐$_8$ Doctoral degree (PhD, MD, EdD, DDS, JD, etc.)........ Major: ______________

7. What certifications do you currently possess? (Check all that apply)

☐$_1$ CPE - Certified Professional Ergonomist
☐$_2$ CHFP - Certified Human Factors Professional
☐$_3$ CEA - Certified Ergonomist Associate
☐$_4$ AHFP - Associate Human Factors Professional
☐$_5$ Other (please specify) ______________________
☐$_6$ Other (please specify) ______________________
☐$_7$ Other (please specify) ______________________
☐$_8$ Other (please specify) ______________________
☐$_9$ Not applicable

Occupational Background

8. What is your current job title? ________________________

9. How long have you been in your current position (years)? ______________

10. What market sector best describes the type of organization in which you work? (Check one)

☐$_1$ For-profit business
☐$_2$ Nonprofit business
☐$_3$ University/academia - public
☐$_4$ University/academia - private
☐$_5$ Government/military
☐$_6$ Self-employed
☐$_7$ Other (please specify) ______________________________

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11. Approximately how many people work at your place of employment (including all divisions and locations)? (Check one)

☐$_1$ 25 or fewer
☐$_2$ 26 - 99
☐$_3$ 100 - 499
☐$_4$ 500 - 1,499
☐$_5$ 1500 or more
☐$_6$ N/A

Additional information:

12. Approximately how many task analyses have you conducted in your professional experience? (Check one)

☐$_1$ Fewer than 5
☐$_2$ 6-12
☐$_3$ 13-50
☐$_4$ More than 50

Comments:

____

____

13. How many task analyses have you conducted in the past (1) year? ____________

Comments:

____

____

14. For what purposes do you use task analysis?
(Check all that apply and rank in order of frequency used)

Purpose	**Rank (1 = most frequent)**
☐$_1$ Equipment & product design	
☐$_2$ Task design	
☐$_3$ Environmental design	
☐$_4$ Training of individuals	
☐$_5$ Selection of individuals	
☐$_6$ Other: ____________	
☐$_7$ Other: ____________	

Comments:

____

____

15. What is the main goal of your task analysis?
(Check all that apply and rank in order of frequency used)

Goal	**Rank (1 = most frequent)**
☐$_1$ Enhance performance	
☐$_2$ Increase safety	
☐$_3$ Increase comfort	
☐$_4$ Increase user satisfaction	
☐$_5$ Other: ____________	
☐$_6$ Other: ____________	

Comments:

____

____

18. In the table below, please indicate
(a) what task analysis method(s) you generally use or have you used in your work (if you use a combination of methods, please specify)
(b) approximately what year you learned it
(c) how you learned it
(d) your self-rated proficiency

Task analysis method (please specify)	**Frequency used** 1 = never 2 = yearly or less often 3 = monthly 4 = weekly 5 = daily	**When learned** Estimate what year it was, e.g., 2001	**How learned** (e.g., workshop, course, tutorial, book, on the job)	**Your self-rating** 1 = not very proficient 2 3 4 5 = very proficient

Comments:

16. What kinds of tasks have you analyzed in the past?

17. Please rate what you generally emphasize in your task analyses:

	No emphasis				**Lot of emphasis**
Actions (steps)........................	□1	□2	□3	□4	□5
Affective aspects	□1	□2	□3	□4	□5
Cognitive aspects	□1	□2	□3	□4	□5
Descriptive aspects .... (how a task is done)	□1	□2	□3	□4	□5
Goals and subgoals.....................	□1	□2	□3	□4	□5
Motor aspects	□1	□2	□3	□4	□5
Normative aspects .... (how a task should be done)	□1	□2	□3	□4	□5
Sensory/perceptual aspects	□1	□2	□3	□4	□5

Other (please specify) ____________________

Comments:

19. We also would like to learn whether you are using the specific task analysis methods listed below. For the ones you have not already mentioned on the previous page, please indicate:
(a) If you generally use or have you used the method in your work (if you use it in a combination with other methods, please specify)
(b) approximately what year you learned it
(c) how you learned it
(d) your self-rated proficiency

Task analysis method (please specify)	**Frequency used** 0 = never heard of 1 = never 2 = yearly or less often 3 = monthly 4 = weekly 5 = daily	**When learned** Estimate what year it was, e.g., 2001	**How learned** (e.g., workshop, course, tutorial, book, on the job)	**Your self-rating** 1 = not very proficient 2 3 4 5 = very proficient
Abstraction-Decomposition Space				
Goal-Directed Task Analysis				
Hierarchical Task Analysis				
Subgoal-Template				
Cognitive Task Analysis (please specify)				

Comments:

Comments (continued):

Please continue on the next page.

B.3 Task Questionnaire

Task Questionnaire

Making a peanut butter jelly sandwich

A. How familiar are you with making a peanut butter jelly sandwich?

☐$_1$ not very familiar	☐$_2$	☐$_3$	☐$_4$	☐$_5$ very familiar

B. How frequently do you make a peanut butter jelly sandwich?

☐$_1$ never	☐$_2$ yearly or less often	☐$_3$ monthly	☐$_4$ weekly	☐$_5$ daily

Making breakfast

A. How familiar are you with making breakfast?

☐$_1$ not very familiar	☐$_2$	☐$_3$	☐$_4$	☐$_5$ very familiar

B. How frequently do you make breakfast?

☐$_1$ never	☐$_2$ yearly or less often	☐$_3$ monthly	☐$_4$ weekly	☐$_5$ daily

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Making Vetkoek

A. How familiar are you with making Vetkoek?

☐$_1$ not very familiar	☐$_2$	☐$_3$	☐$_4$	☐$_5$ very familiar

B. How frequently do you make Vetkoek?

☐$_1$ never	☐$_2$ yearly or less often	☐$_3$ monthly	☐$_4$ weekly	☐$_5$ daily

Making a phone call

A. How familiar are you with making a phone call?

☐$_1$ not very familiar	☐$_2$	☐$_3$	☐$_4$	☐$_5$ very familiar

B. How frequently do you make a phone call?

☐$_1$ never	☐$_2$ yearly or less often	☐$_3$ monthly	☐$_4$ weekly	☐$_5$ daily

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Arranging a meeting

A. How familiar are you with arranging a meeting?

☐1	☐2	☐3	☐4	☐5
not very familiar				very familiar

B. How frequently do you arrange a meeting?

☐1	☐2	☐3	☐4	☐5
never	yearly or less often	monthly	weekly	daily

Sharing pictures using Adgers

A. How familiar are you with sharing pictures using Adgers?

☐1	☐2	☐3	☐4	☐5
not very familiar				very familiar

B. How frequently do you share pictures using Adgers?

☐1	☐2	☐3	☐4	☐5
never	yearly or less often	monthly	weekly	daily

Comments:

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B.4 Task Analysis Questionnaire

Task Analysis Questionnaire

A. Please list and briefly describe five main features of the Task Analysis method you just used

1) ____________________

2) ____________________

3) ____________________

4) ____________________

5) ____________________

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Making a peanut butter jelly sandwich

A. How easy or difficult it was to perform the task analysis on making a peanut butter jelly sandwich?

☐1 very easy ☐2 ☐3 ☐4 ☐5 very difficult

B. How confident are you in your task analysis of making a peanut butter jelly sandwich?

☐1 not very confident ☐2 ☐3 ☐4 ☐5 very confident

C. How representative is your task analysis of making a peanut butter jelly sandwich compared to the ones in your professional work?

☐1 not very representative ☐2 ☐3 ☐4 ☐5 very representative

If not representative, please explain:

____

D. How did you go about breaking down the task?

____

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Making breakfast

A. How easy or difficult it was to perform the task analysis on making breakfast?

☐1	☐2	☐3	☐4	☐5
very easy				very difficult

B. How confident are you in your task analysis of making breakfast?

☐1	☐2	☐3	☐4	☐5
not very confident				very confident

C. How representative is your task analysis of making breakfast compared to the ones in your professional work?

☐1	☐2	☐3	☐4	☐5
not very representative				very representative

If not representative, please explain:

____

____

____

D. How did you go about breaking down the task?

____

____

____

Making Vetkoek

A. How easy or difficult it was to perform the task analysis on making Vetkoek?

☐1	☐2	☐3	☐4	☐5
very easy				very difficult

B. How confident are you in your task analysis of making Vetkoek?

☐1	☐2	☐3	☐4	☐5
not very confident				very confident

C. How representative is your task analysis of making Vetkoek compared to the ones in your professional work?

☐1	☐2	☐3	☐4	☐5
not very representative				very representative

If not representative, please explain:

____

____

____

D. How did you go about breaking down the task?

____

____

____

Making a phone call

A. How easy or difficult it was to perform the task analysis on making a phone call?

☐$_1$	☐$_2$	☐$_3$	☐$_4$	☐$_5$
very easy				very difficult

B. How confident are you in your task analysis of making a phone call?

☐$_1$	☐$_2$	☐$_3$	☐$_4$	☐$_5$
not very confident				very confident

C. How representative is your task analysis of making a phone call compared to the ones in your professional work?

☐$_1$	☐$_2$	☐$_3$	☐$_4$	☐$_5$
not very representative				very representative

If not representative, please explain:

D. How did you go about breaking down the task?

Arranging a meeting

A. How easy or difficult it was to perform the task analysis on arranging a meeting?

☐$_1$	☐$_2$	☐$_3$	☐$_4$	☐$_5$
very easy				very difficult

B. How confident are you in your task analysis of arranging a meeting?

☐$_1$	☐$_2$	☐$_3$	☐$_4$	☐$_5$
not very confident				very confident

C. How representative is your task analysis of arranging a meeting compared to the ones in your professional work?

☐$_1$	☐$_2$	☐$_3$	☐$_4$	☐$_5$
not very representative				very representative

If not representative, please explain:

D. How did you go about breaking down the task?

Sharing pictures using Adgers

A. How easy or difficult it was to perform the task analysis on sharing pictures using Adgers?

☐1	☐2	☐3	☐4	☐5
very easy				very difficult

B. How confident are you in your task analysis of sharing pictures using Adgers?

☐1	☐2	☐3	☐4	☐5
not very confident				very confident

C. How representative is your task analysis of sharing pictures using Adgers compared to the ones in your professional work?

☐1	☐2	☐3	☐4	☐5
not very representative				very representative

If not representative, please explain:

D. How did you go about breaking down the task?

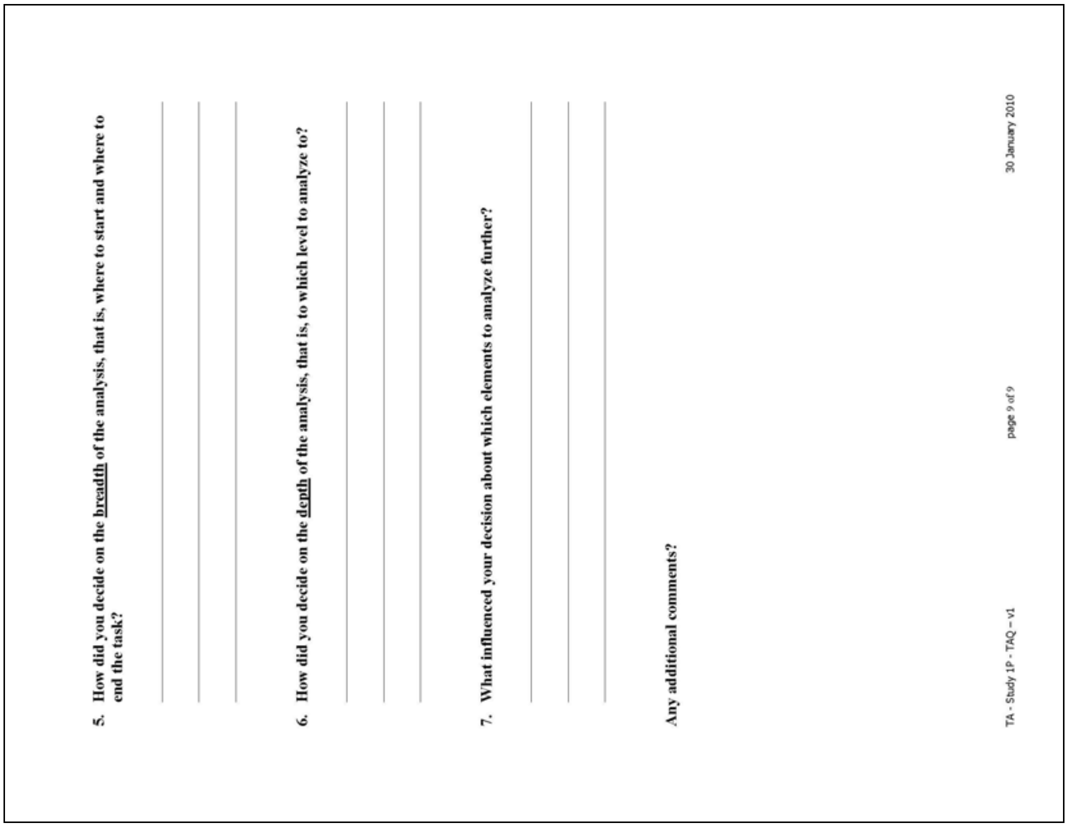
Thinking back to all the task analyses you just performed

1. **What aspects of the task analysis were easy to perform? Please explain.**

2. **What aspects of the task analysis were difficult to perform? Please explain.**

3. **How did you identify the goals and sub-goals?**

4. **How did you show the order of the task elements?**



5. How did you decide on the <u>breadth</u> of the analysis, that is, where to start and where to end the task?

6. How did you decide on the <u>depth</u> of the analysis, that is, to which level to analyze to?

7. What influenced your decision about which elements to analyze further?

Any additional comments?

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B.5 Scenario

For the next section, please consider the following scenario. Imagine that you have started working on a new project with new team members. To create common ground your team members ask you to illustrate your understanding of task analysis on a number of example tasks. They also would like you to think aloud as you go through the examples, as you just have practiced.

Overall there will be six tasks to analyze in this portion of the study. Please put down your pen/pencil as a signal that you are done. You will have 15 minutes for each task analysis. Once either the 15 minutes have ended or you finished your task analysis, I will give you the next task to analyze.

Do you have any questions at this point?

B.6 Questions of Semi-structured Interview

Now we will be begin the structured interview, and for this I will start the audio recording. The following questions relate to task analysis in general. I would like you to please think about task analysis in general and becoming proficient at it. Are you ready?

- What do you find are some common challenges in conducting a task analysis?
- How do you resolve these challenges? (or what do you in response to that?)
- What do you find are the main challenges in *learning* how to conduct a task analysis?
- What are challenges in *teaching* novices about task analysis?
- What errors do you see novices in task analysis often make?
- How do you personally define 'expertise' in task analysis?
- How do you recognize expertise in task analysis?
- What products typically emerge from your task analysis?
- How are these products typically used?
- If you encounter common problems with task analysis products, what are those?
- What do you consider good qualities of a task analysis?
- For which domains do you usually conduct task analyses for?
- What tasks do you usually analyze?

Now thinking back to the process of actually conducting the task analysis:

- In which respects are the task analyses you just completed representative of the task analyses that you conduct professionally?
- How would you describe the general approach to task analysis you use?
- Do you sometimes need to adjust the task analysis method you use, and if so, in which manner?

The next set of questions are to learn how you generally conduct task analyses on your job. First, please think back to a task analysis (or a part of a task analysis) that went well and you were pleased with the outcome while I'm asking you the following questions … Do you have something in mind?

- Were you part of a team doing the task analysis, and if yes, what was your role in the team?
- What goals were you trying to accomplish as you performed the task analysis?
- What was easy about the task analysis?
- What were some key decisions you made?
- What information did you use?
- How did you identify goals and sub-goals?
- What helped you identifying the goals and sub-goals?
- How did you differentiate between goals and actions?
- How did you show the order of the task elements?
- What helped you determine the breadth of the analysis, that is, where to start and where to end the task, so, what to include?
- What helped you decide on the depth of the analysis, that is, to which level to analyze to?
- What influenced your decision about which elements to analyze further?

Now please think back to a task analysis, or a part of a task analysis, that was challenging while I'm going to ask you many of the same questions.

- Were you part of a team doing the task analysis, and if yes, what was your role in the team?
- What goals were you trying to accomplish as you performed the task analysis?
- What was challenging about the task analysis?
- How did you go about resolving the challenge?
- What are some key decisions you made?
- What information did you use?
- How did you identify goals and sub-goals?
- What helped you identifying the goals and sub-goals?
- How did you differentiate between goals and actions?
- How did you show the order of the task elements?
- What helped you determine the breadth of the analysis, that is, where to start and where to end the task, so, what to include?
- What helped you decide on the depth of the analysis, that is, to which level to analyze to?
- What influenced your decision about which elements to analyze further?

Thank you for your interview. I will now turn off the audio recording.

B.7 Study Protocol

I. Informed consent

II. Administer/collect Demographics and Experience Questionnaire

III. Core phase
   a. *Start video recording*

   b. Think-aloud training
      i. Provide instructions
      ii. Practice using tic-tac-toe

   c. Conduct task analyses
      i. Provide participant with task
      ii. Observe, and remind participant to think aloud if needed
      iii. Collect task analysis
      iv. Repeat twice
      v. Break after 3 task analyses

   d. *Stop video recording*

   e. Administer/collect Task Questionnaire
   f. Administer/collect Task Analysis Questionnaire

   g. *Start audio recording*

   h. Semi-structured interview

   i. *Stop audio recording*

IV. Debriefing

V. Compensation

B.8 Consent Form

Georgia Institute of Technology

Project Title: Understanding Task Analysis

Investigators: Dr. Arthur D. Fisk & Dr. Wendy A. Rogers (Principal Investigators) – Anne E. Adams (Student Investigator)

Protocol and Consent Title: *Understanding Task Analysis – 17/Feb/2010v2*

Purpose:

You are being asked to be a volunteer in a research study. The purpose of this form is to tell you about the tasks you will be asked to complete today and to inform you about your rights as a research volunteer. Feel free to ask any questions that you may have about the study, what you will be asked to do, and so on.

Thank you for your interest in participating in the study. Our work could not be completed without the help of volunteers. The purpose of this study is to understand the processes and experience involved in conducting a task analysis as well as the characteristics of the resulting task analysis products. In this study we will observe and record how you conduct a task analysis of common tasks as well as inquire about your thoughts and experience with conducting a task analysis. We expect to enroll 30 people in this study.

Exclusion/Inclusion Criteria:

Participants in this study must be native English speakers, have at least two years of experience conducting a task analysis on the job and conducted at least one task analysis in the past year.

Procedures:

If you decide to be in this study, you will be asked to complete a demographic and task analysis experience questionnaire. Then we will ask you to conduct a task analysis, the way you normally would, using six common example tasks. We will ask you to think aloud about what you are doing while you conduct the task analyses. After you have finished the task analyses, we will gather written feedback on the tasks and task analyses you just completed. An interview will follow during which we will ask questions to help us understand your general approach to task analysis as well as challenges you encounter. To ensure that your responses are accurately documented we will video-record you while you are completing the task analyses and tape-record the interview.

Remember that you will receive full instructions on every task. It is important that everyone understands the instructions before beginning the tasks. Because we are trying to measure a range of abilities, some of the tasks are very simple, and others are quite difficult. If anything is unclear at any time, please do not hesitate to ask questions. This one-day study will take approximately 3 hours of your time. You may stop at any time and for any reason.

Risks/Discomforts

The following risks/discomforts may occur as a result of your participation in this study. Participation in this study involves minimal risk or discomfort to you. Risks are minimal and do not exceed those of normal office work. Please tell us if you are having trouble with any task.

Benefits

You are not likely to benefit in any way from joining this study. But we hope that others will benefit from what we find in doing this study.

APPROVED Consent Form Approved by Georgia Tech IRB: March 04, 2010 - July 19, 2010

Compensation to You

You will receive $50 for your participation in the study. Given that we will require a large amount of data from each person, the testing session lasts for approximately 3 hours. If you do not complete the study, you will still be compensated with $50 for your time.

Confidentiality

The following procedures will be followed to keep your personal information confidential in this study: All written/audio/video data that are collected about you will be kept private to the extent allowed by law. To protect your privacy, your written/audio/video records will be kept under a code number rather than by name. Your written/audio/video records will be kept in locked files and only study staff will be allowed to look at them. Your name and any other fact that might point to you will not appear when results of this study are presented or published. We will destroy the *audio tapes* after they have been transcribed and verified.

We may use clips from the *video recordings* in research presentations to other academics and the public. The cameras will focus on the paper and what you are writing, and thus intended to capture your hands and not your face. Please, select ONE of the following options for use of audio/video recordings by initialing your preference below.

Option 1: If you are willing to allow us to use a video recording of any portion of your session, please initial here _______. If you have initialed here, we may use a portion of your interview in a presentation, for example, but you will never be identified by name.

Option 2: If you would prefer that we use information from your video recording only in transcribed form (rather than as a video clip), please initial here ________.

Confidentiality cannot be guaranteed; your personal information may be disclosed if required by law. This means that there may be rare situations that require us to release personal information about you, for example, in case a judge requires such release in a lawsuit or if you tell us of your intent to harm yourself or others (including reporting behaviors consistent with child abuse).

To make sure that this research is being carried out in the proper way, the Georgia Institute of Technology IRB will review study records. The Office of Human Research Protections may also look at study records.

Because each individual's data and test scores are confidential, we cannot mail your individual results.

Costs to You

There are no costs to you associated with participating in this study.

In Case of Injury/Harm:

If you are injured as a result of being in this study, please contact Dr. Arthur D. Fisk at 404-894-6066 or Dr. Wendy A. Rogers at 404-894-6775. Neither the Georgia Institute of Technology nor the principal investigators have made provision for payment of costs associated with any injury resulting from participation in this study.

Research Participant Rights

- Your participation in this study is voluntary. You do not have to be in this study if you don't want to be.
- You have the right to change your mind and leave the study at any time without giving any reason and without penalty.
- Any new information that may make you change your mind about being in this study will be given to you.
- You will be given a copy of this consent form to keep.
- You do not waive any of your legal rights by signing this consent form.

Questions about the Study or Your Rights as a Research Participant

- If you have any questions about the study, you may contact the investigator obtaining consent (listed below) at 404-385-0798.
- If you have any questions about your rights as a research participant, you may contact Ms. Kelly Winn, Georgia Institute of Technology, Office of Research Compliance, at (404) 385-2175.

If you sign below, it means that you have read (or have had read to you) the information given in this consent form, and you would like to be a volunteer in this study.

____

Participant Name (please print)

____

Participant Signature **Date**

____

Name of Investigator Obtaining Consent (please print)

____

Signature of Investigator Obtaining Consent **Date**

B.8 Debriefing

Understanding Task Analysis 10 March 2010

Debriefing Information

Thank you very much for participating in this study. This study was conducted to help us understand the skills involved in conducting a task analysis by investigating the process and products of task analysis. The skills involved in functional task analysis are not well-understood, and functional task analysis methods are often labeled as being "difficult". The goal of this study is to better understand what makes task analysis difficult and how people experienced in conducting task analysis meet this challenge. For example, how do participants differentiate and organize the elements of a task, and how do they resolve the ambiguity of elements?

This study is expected to bring about valuable information about the process of conducting task analysis, the cues experienced task analysts attend to, the decisions they make, the strategies they use, and the characteristics of their task analysis products. The results are expected to lead to categories that allow characterizing performance and inform the design of training.

If you are interested, we will share a summary of the results with you by mailing you a newsletter at your request. Because each individual's data and test scores are confidential, there will be no way for us to mail your individual results. Your data will provide valuable insight into understanding the characteristics of task analysis processes and products. Your experimenter was Anne Adams. If you have any questions, please feel free to contact us.

Thank you for your time and cooperation.

Human Factors and Aging Laboratory

Georgia Institute of Technology (404) 894-8344

Dr. Arthur D. Fisk and Dr. Wendy A. Rogers

APPENDIX C: STUDY 1 - RESULTS

C.1 Coding Scheme for Task Analysis Products

(1) Hierarchy dimensions

A hierarchy is characterized by the depth and breadth of the analysis. Code each task analysis product on both dimensions, using the number that creates the most depth. (see Table C.1). For lists, count the number of bullets or lines for breadth and the number of sub-levels for depth. For flowcharts, a single arrow or two branches combining to one indicate an increase in breadth. Branching indicates an increase in depth rather than breadth, thus two arrows increase the depth by one. For example “A → B → C “ means a breadth of 3 and depth of 1, and “A → B double-arrow to C and D” means a breadth of 2 and a depth of 2. For paragraphs/text, the breadth is the number of paragraphs. If there is only one paragraph, then breadth is the number of sentences. Depth is the number of sentences within a paragraph, separated by a period. Listings within a sentence are considered sublevels on the same level. Two if-statements increase depth by one.

Table C.1

Coding Scheme for Breadth and Depth of the Task Analysis

Code	Explanation	Example
Breadth @ level 1	The high-level goal is designated as level 0. Code the number of elements @ level 1, so not including the high-level goal	1. locate phone 2. decide who to call 3. find name in phone 4. press call (Breadth =3)
Depth (maximum)	Number of elements deep **at most**. The high-level goal is level 0 and not counted for depth.	1. locate phone 2. decide who to call 3. find name in phone 4. press call (Depth = 1)

(2) Subgoals

Determine whether participants' subgoals are found somewhere in the Master Task Analysis created for each task. Subgoals are operationally defined as verb-noun pairs. If a verb-noun pair is not in the Master Task Analysis, code it as "extra". If a verb-noun pair is more specific than a subgoal, add an "x" to that super-ordinate subgoal to indicate its sub-ordinate status. Do not count "repeat" loops because this information is in the plan and we are interested in the *different* subgoals participants extract.

(3) Versatility

Versatility refers to whether the task analysis can be applied to various implementations. Evaluate whether the task analysis contains mentioning of a specific technology, ingredient, equipment and so forth. If none is mentioned (or at least three different ones), then the task analysis receives the code of "general". If a specific technology, ingredient, equipment and so forth is mentioned, then the task analysis receives the code "specific" (see Table C.2).

Table C.2

Coding Scheme for Versatility

Code	Explanation	Example
General	Does not specifically mention a technology, ingredient, or location (or more than 2)	Goal: To make a cup of tea. - Prepare water to make tea - Acquire the correct amount of water
Specific	Mentions a specific technology or ingredient.	Goals: Make a phone call. - Go to Verizon and buy phone - Flip open phone - Select number from contacts - Press "send"

C.2 Reliabilities for Coding in Study 1

Table C.3

Coder Agreement for Task Analysis Products and Process

Category	Percent Agreement	Cohen's Kappa
Task Analysis Products		
Making sandwich	85.6%	.83
Making breakfast	84.1%	.82
Making Vetkoek	85.6%	.84
Making phone call	82.4%	.78
Arranging meeting	81.8%	.79
Sharing pictures	74.8%	.69
Task Analysis Process	86.4%	.83

Note. Coding reliabilities are not adjusted for disagreements in segmentation.

C.3 Breadth and Depth Statistics

Table C.4

Wilcoxon Pairwise Comparisons for Breadth and Depth

Comparison	Breadth		Depth	
	Z	*p*	Z	*p*
Sandwich-Breakfast	- 1.362	.173	- 1.134	.257
Sandwich-Vetkoek	- 1.970	.049	- 1.732	.083
Sandwich-Phone	- 2.524	.012	- 1.342	.180
Sandwich-Meeting	- 1.122	.262	- .707	.480
Sandwich-Adgers	- 1.474	.141	- .276	.783
Breakfast-Vetkoek	- 1.261	.207	.000	1.000
Breakfast-Phone	- 2.106	.035	- .333	.739
Breakfast-Meeting	- .169	.866	.000	1.000
Breakfast-Adgers	- .561	.574	- .647	.518
Vetkoek-Phone	- 1.983	.047	.000	1.000
Vetkoek-Meeting	- 1.198	.231	.000	1.000
Vetkoek-Adgers	- .632	.527	- .707	.480
Phone-Meeting	- 1.951	.051	- .106	.915
Phone-Adgers	- 1.362	.173	- .333	.739
Meeting-Adgers	- .849	.396	- .412	.680

Note. Bonferroni-adjusted alpha-level p= .05 : 6 = .008.

C.4 Breadth and Depth of Task Analysis Products

Table C.5

Breadth and Depth of All Task Analyses

Tasks	Breadth				Depth			
	M	*SD*	*Min*	*Max*	*M*	*SD*	*Min*	*Max*
Cooking								
Sandwich	10.13	6.60	4	21	2.00	.53	1	3
Breakfast	6.75	4.46	2	14	2.50	1.20	1	5
Vetkoek	4.88	2.75	2	11	2.38	.52	2	3
Communication								
Phone	3.38	2.00	2	8	2.38	.92	1	4
Meeting	6.25	2.87	2	9	2.38	1.51	1	6
Adgers	5.25	2.66	2	10	2.13	.83	1	3

Note. Data are from eight task analyses per task.

C.5 Coding Scheme for Task Analysis Process

(1) Breadth or depth first

Materials needed for coding are task analyses and think-aloud data. There are three possible codes: Breadth-first, depth-first, and other (see Table C.6)

Table C.6

Coding Scheme for Breadth and Depth-First

Code	Explanation	Example
Breadth-first	Participant first hits the high-level subgoal and then attends to the lower levels ones. Code here also, if there is no hierarchy	*Get ingredients, prepare ingredients, and eat. To get ingredients you'd make a list and buy groceries. To prepare ingredients..*
Depth-first	The key is that the participant starts going into depth before having outlined all high-level subgoals. Code here also, if participant mentions more than two high-level subgoals and only goes into depth with the third or fourth one.	*Get ingredients, make list, go to the car, buy groceries, return home. Prepare ingredients..*
Other	Code here, if the approach does not appear to fit either category above.	

(2) Questions

Materials needed for coding are the think-aloud data. Assign the code of "who", "what", "where", "when", "why", and "how". Be specific to the phrasing of the participant and do interpret. For example, the question of "what date" should be coded as "what" and not "when". If a question does not fit in any of the categories, code as "other.

APPENDIX D: STUDY 2 - MATERIALS

D.1 General Introduction to HTA

<u>An Introduction to Hierarchical Task Analysis</u>

Hierarchical Task Analysis (HTA) was first proposed in the late 1960s as a general approach to examining tasks. Since then, it has become widely adopted although the method is often applied unsystematically or in ways that fail to ensure its full benefit. The aim of this introduction is to present the ideas of HTA.

Any effort to improve human performance in a work or recreational setting must start by some understanding of what people are required to do and how they achieve their goals. Methods for achieving this understanding are often referred to as task analysis. Thus task analysis methods are an important prerequisite to the organization of work, the design of workplaces, work practices and equipment, and in helping people to master their tasks. Task analysis methods, therefore, should be of direct interest to managers and engineers concerned with setting up and organizing tasks, to designers concerned with making sure people can use equipment properly, to managers and supervisors concerned with making sure that tasks work according to design, to human factors and other management support staff concerned with prescribing conditions to enable people to work effectively, to human resource staff concerned with personnel and training issues, and to safety staff concerned to ensure that safe practices are followed.

In HTA, tasks are represented in terms of hierarchies of *goals* and *subgoals*, using the idea of *plans* to show when subgoals need to be carried out. In task analysis, it is always important to think of the reason why the task is carried out. For example, a toaster is used to obtain toast, by cooking ordinary bread to the satisfaction of the person who is to eat it. Thus the task has a purpose or goal and criteria against which the toast can be judged to be satisfactory or otherwise. Setting the criteria for industrial, commercial and service goals includes specification of the product and constraints on how it is achieved. These constraints can include cost and safety criteria. Thus, motor cars are manufactured to be capable of transporting passengers according to the criterion of speed and acceleration, but this cannot be achieved at the expense of comfort and safety.

Detailed criteria can rarely be specified at the outset of a design process, even in product design. As designs are developed and intermediate design problems are solved, so new aspects of the product and its manufacture are discovered. To achieve a suitable level of power for a new vehicle, for example, a larger engine than had been initially envisaged may need to be included. This immediately places greater constraints on the size and layout of other components, so detailed design criteria are modified.

This process of refining criteria also arises when tasks are examined. As aspects of the task are uncovered, we realize increasingly what needs to be valued in terms of performance. For example, a task analysis might commence with the aim of improving human performance to gain greater productivity. Notions of safety may be uppermost, but only when task detail is understood are the implications of safety properly appreciated.

Just as a task has a purpose, so too does the task analyst's intervention in doing task analysis. The analyst might be involved in training, or developing a better control panel, or determining how people can work together most effectively, or several of these things. Task analysis should not be done for the sake of it; knowing why we are carrying out the analysis affects how the analysis progresses.

Plans are crucial to HTA. A plan only makes sense in conjunction with the subgoals it is governing. Thus, to refer back to our example of the toaster, we can use a plan which states that first we must ensure power to the toaster, then we must insert the bread, then we push down the lever, then when the toast pops up, we remove the toast. If the toast is satisfactory we can terminate the toaster operation. If the toast is unsatisfactory we can adjust the toaster then repeat part of the previous activity.

Carrying out HTA on any task entails similar processes to those described for using the toaster. HTA works towards understanding what is necessary to achieve the stated goal. The analyst keeps in mind the performance criteria involved. As the analysis proceeds, the criteria for performance and why these different things are important start to make more sense.

D.2 Additional Instructions (Training Condition = Steps)

Procedural Steps of Hierarchical Task Analysis

1. *Define the purpose of the analysis*

   Examples of different purposes would include task design, interface design, and training design.

2. *Define the boundaries of the task description*

   In other words, perform the analysis appropriate to the intended purpose to which it is to be put.

3. *Try to access a variety of sources of information about the task to be analyzed*

   Gather as much information as possible about the task that you are attempting to analyze.

4. *Describe the task goals*

   State the initial goals of the task

5. *Redescribe the task goals into subgoals*

   As goals are broken down and new operations emerge, subgoals for each of the operations need to be identified. Check adequacy of redescription.

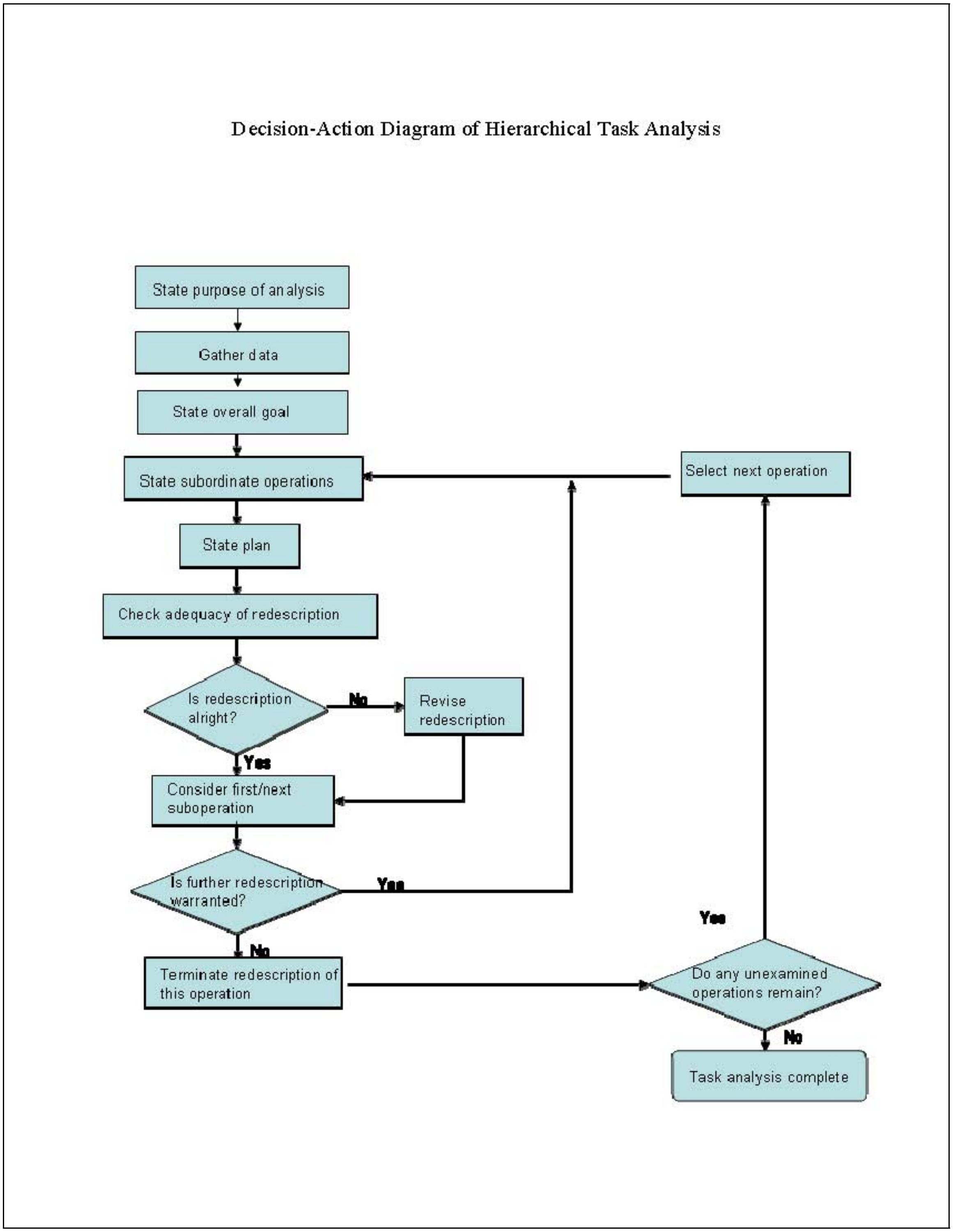
6. *Link goals to subgoals and describe the conditions under which subgoals are triggered*

   Plans are the control structures that enable the analyst to capture the conditions which trigger the subgoals under any super-ordinate goal. They are read from the top of the hierarchy down to the subgoals that are triggered and back up the hierarchy again as the exit conditions are met. Exit conditions are important to ensure an end to the analysis.

7. *Stop re-describing the subgoals when you judge the analysis is fit for purpose*

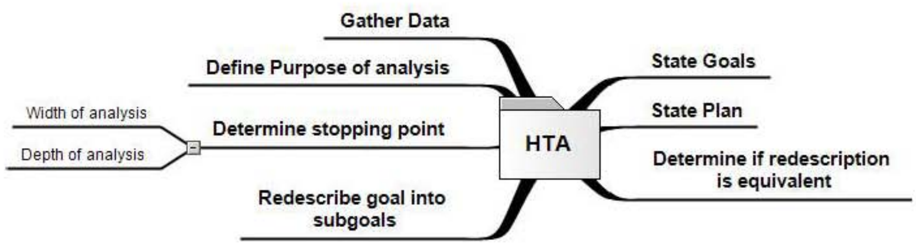
   The level of description is likely to be highly dependent upon the purpose of the analysis, so it is conceivable that a stopping rule could be generated at that point in the analysis.

D.3 Additional Instructions (Training Condition = Decision-Action)

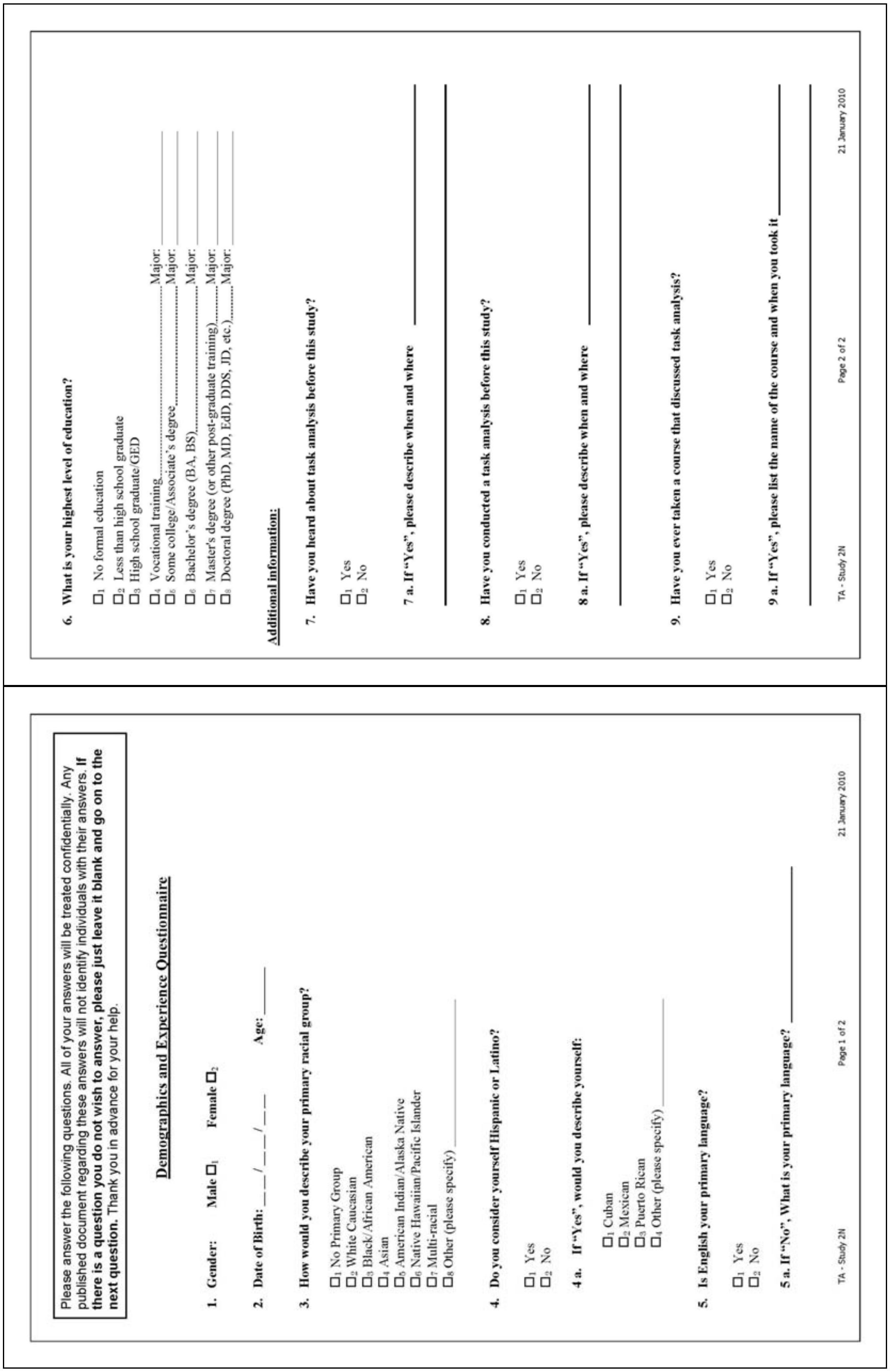


D.4 Additional Instructions (Training Condition = Concept Map)

Concept Map of Hierarchical Task Analysis



D.5 Demographics and Experience Questionnaire



Please answer the following questions. All of your answers will be treated confidentially. Any published document regarding these answers will not identify individuals with their answers. **If there is a question you do not wish to answer, please just leave it blank and go on to the next question.** Thank you in advance for your help.

Demographics and Experience Questionnaire

1. Gender: **Male** ☐1 **Female** ☐2

2. Date of Birth: __ __ / __ __ / __ __ **Age:** ______

3. How would you describe your primary racial group?

☐1 No Primary Group
☐2 White Caucasian
☐3 Black/African American
☐4 Asian
☐5 American Indian/Alaska Native
☐6 Native Hawaiian/Pacific Islander
☐7 Multi-racial
☐8 Other (please specify) ____________

4. Do you consider yourself Hispanic or Latino?

☐1 Yes
☐2 No

4 a. If "Yes", would you describe yourself:

☐1 Cuban
☐2 Mexican
☐3 Puerto Rican
☐4 Other (please specify) ____________

5. Is English your primary language?

☐1 Yes
☐2 No

5 a. If "No", What is your primary language? ____________

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6. What is your highest level of education?

☐1 No formal education
☐2 Less than high school graduate
☐3 High school graduate/GED
☐4 Vocational training........Major: ________
☐5 Some college/Associate's degree........Major: ________
☐6 Bachelor's degree (BA, BS)........Major: ________
☐7 Master's degree (or other post-graduate training)........Major: ________
☐8 Doctoral degree (PhD, MD, EdD, DDS, JD, etc.)........Major: ________

Additional information:

7. Have you heard about task analysis before this study?

☐1 Yes
☐2 No

7 a. If "Yes", please describe when and where ____________

8. Have you conducted a task analysis before this study?

☐1 Yes
☐2 No

8 a. If "Yes", please describe when and where ____________

9. Have you ever taken a course that discussed task analysis?

☐1 Yes
☐2 No

9 a. If "Yes", please list the name of the course and when you took it ____________

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D.6 Task Questionnaire

Task Questionnaire

Making a peanut butter jelly sandwich

A. How familiar are you with making a peanut butter jelly sandwich?

☐1	☐2	☐3	☐4	☐5
not very familiar				very familiar

B. How frequently do you make a peanut butter jelly sandwich?

☐1	☐2	☐3	☐4	☐5
never	yearly or less often	monthly	weekly	daily

Making breakfast

A. How familiar are you with making breakfast?

☐1	☐2	☐3	☐4	☐5
not very familiar				very familiar

B. How frequently do you make breakfast?

☐1	☐2	☐3	☐4	☐5
never	yearly or less often	monthly	weekly	daily

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Making Vetkoek

A. How familiar are you with making Vetkoek?

☐1	☐2	☐3	☐4	☐5
not very familiar				very familiar

B. How frequently do you make Vetkoek?

☐1	☐2	☐3	☐4	☐5
never	yearly or less often	monthly	weekly	daily

Making a phone call

A. How familiar are you with making a phone call?

☐1	☐2	☐3	☐4	☐5
not very familiar				very familiar

B. How frequently do you make a phone call?

☐1	☐2	☐3	☐4	☐5
never	yearly or less often	monthly	weekly	daily

TA - Study 2N - TQ – v1 page 2 of 3 21 January 2010

Arranging a meeting

A. How familiar are you with arranging a meeting?

☐1	☐2	☐3	☐4	☐5
not very familiar				very familiar

B. How frequently do you arrange a meeting r?

☐1	☐2	☐3	☐4	☐5
never	yearly or less often	monthly	weekly	daily

Sharing pictures using Adgers

A. How familiar are you with sharing pictures using Adgers?

☐1	☐2	☐3	☐4	☐5
not very familiar				very familiar

B. How frequently do you share pictures using Adgers?

☐1	☐2	☐3	☐4	☐5
never	yearly or less often	monthly	weekly	daily

Comments:

TA - Study 2N - TQ – v1 page 3 of 3 21 January 2010

D.7 Task Analysis Questionnaire

Task Analysis Questionnaire

A. Please list and briefly describe five main features of Hierarchical Task Analysis

1) ______________________________

____

2) ______________________________

____

3) ______________________________

____

4) ______________________________

____

5) ______________________________

____

TA - Study 2N - TAQ – v1 page 1 of 9 21 January 2010

Making a peanut butter jelly sandwich

A. How easy or difficult it was to perform the task analysis on making a peanut butter jelly sandwich?

☐1 very easy ☐2 ☐3 ☐4 ☐5 very difficult

B. How confident are you in your task analysis of making a peanut butter jelly sandwich?

☐1 not very confident ☐2 ☐3 ☐4 ☐5 very confident

A. How did you go about breaking down the task?

____

____

____

TA - Study 2N - TAQ – v1 page 2 of 9 21 January 2010

Making breakfast

A. How easy or difficult it was to perform the task analysis on making breakfast?

☐ $_1$ very easy	☐ $_2$	☐ $_3$	☐ $_4$	☐ $_5$ very difficult

B. How confident are you in your task analysis of making breakfast?

☐ $_1$ not very confident	☐ $_2$	☐ $_3$	☐ $_4$	☐ $_5$ very confident

B. How did you go about breaking down the task?

Making Vetkoek

A. How easy or difficult it was to perform the task analysis on making Vetkoek?

☐ $_1$ very easy	☐ $_2$	☐ $_3$	☐ $_4$	☐ $_5$ very difficult

B. How confident are you in your task analysis of making Vetkoek?

☐ $_1$ not very confident	☐ $_2$	☐ $_3$	☐ $_4$	☐ $_5$ very confident

C. How did you go about breaking down the task?

Making a phone call

D. How easy or difficult it was to perform the task analysis on making a phone call?

☐1 very easy ☐2 ☐3 ☐4 ☐5 very difficult

E. How confident are you in your task analysis of making a phone call?

☐1 not very confident ☐2 ☐3 ☐4 ☐5 very confident

F. How did you go about breaking down the task?

Arranging a meeting

A. How easy or difficult it was to perform the task analysis on arranging a meeting?

☐1 very easy ☐2 ☐3 ☐4 ☐5 very difficult

B. How confident are you in your task analysis of arranging a meeting?

☐1 not very confident ☐2 ☐3 ☐4 ☐5 very confident

G. How did you go about breaking down the task?

Sharing pictures using Adgers

C. How easy or difficult it was to perform the task analysis on sharing pictures using Adgers?

☐1	☐2	☐3	☐4	☐5
very easy				very difficult

D. How confident are you in your task analysis of sharing pictures using Adgers?

☐1	☐2	☐3	☐4	☐5
not very confident				very confident

H. How did you go about breaking down the task?

Thinking back to all the task analyses you just performed

1. **What aspects of HTA were easy to perform? Please explain.**

2. **What aspects of HTA were difficult to perform? Please explain.**

3. **How did you identify the goals and sub-goals?**

4. **How did you show the order of the task elements?**

5. How did you decide on the <u>breadth</u> of the analysis, that is, where to start and where to end the task?

6. How did you decide on the <u>depth</u> of the analysis, that is, to which level to analyze to?

7. What influenced your decision about which elements to analyze further?

Any additional comments?

D.8 Consent Form

Georgia Institute of Technology

Project Title: *Training Novices on Hierarchical Task Analysis*

Investigators: Dr. Arthur D. Fisk & Dr. Wendy A. Rogers (Principal Investigators) – Sarah K. Felipe & Anne E. Adams (Student Investigators)

Research Consent Form (v.1 – March 5, 2009)

Purpose

You are being asked to be a volunteer in a research study. The purpose of this form is to tell you about the tasks you will be asked to complete today and to inform you about your rights as a research volunteer. Feel free to ask any questions that you may have about the study, what you will be asked to do, and so on.

Thank you for your interest in participating in the study. Our work could not be completed without the help of volunteers. The purpose of our research is to provide us with insight into the effectiveness of different types of instructions on performing a Hierarchical Task Analysis. We expect to enroll 40 people in this study.

Exclusion/Inclusion Criteria

Participants in this study must be between the ages of 18 and 28 years, native English speakers, and novices in performing task analysis.

Procedures:

If you decide to be in this study, your part will involve taking a number of general tests that measure your abilities including vision, speed of responding, memory, and vocabulary. Following the general tests we will ask you to start with a sample task analysis. Then you will be given information regarding task analysis and asked to perform the actual analysis on a number of tasks. We will also ask you to complete a demographics questionnaire as well as a questionnaire about the task analyses you completed and your experience in that area.

Remember that you will be given full instructions on every task. It is important that everyone understands the instructions before beginning the tasks. Because we are trying to obtain a range of measures, some of the tasks are very simple, and others a little more difficult. If anything is unclear at any time, please do not hesitate to ask questions. This one-session study will take no more than 2 hours. You may stop at any time and for any reason.

Risks/Discomforts

APPROVED *Consent Form Approved by Georgia Tech IRB: April 01, 2009 - March 31, 2010*

The following risks/discomforts may occur as a result of your participation in this study. Participation in this study involves minimal risk or discomfort to you. Risks are minimal and do not exceed those of normal office work. Please tell us if you are having trouble with any task.

Benefits

You are not likely to benefit in any way from joining this study. But we hope that others will benefit from what we find in doing this study through an improved training program.

Compensation to You

You will receive 1 hour of extra credit for each hour you spend in the study. The time to complete the study is approximately 2 hours, so you will receive 2 hours of extra credit. If you withdraw from the study early for any reason, you will receive 1 credit per hour for your time.

Confidentiality

The following procedures will be followed to keep your personal information confidential in this study: The written data that are collected about you will be kept private to the extent allowed by law. To protect your privacy, your written records will be kept under a code number rather than by name. Your written records will be kept in locked files and only study staff will be allowed to look at them. Your name and any other fact that might point to you will not appear when results of this study are presented or published.

To make sure that this research is being carried out in the proper way, the Georgia Institute of Technology IRB will review study records. The Office of Human Research Protections may also look at study records.

Because each individual's data and test scores are completely confidential, we cannot mail your individual results.

Costs to You

There are no costs to you associated with participating in this study.

In Case of Injury/Harm

If you are injured as a result of being in this study, please contact Dr. Arthur D. Fisk at 404-894-6066 or Dr. Wendy A. Rogers at 404-894-6775. Neither the Georgia Institute of Technology nor the principle investigators have made provision for payment of costs associated with any injury resulting from participation in this study.

Participant Rights

APPROVED *Consent Form Approved by Georgia Tech IRB: April 01, 2009 - March 31, 2010*

- Your participation in this study is voluntary. You do not have to be in this study if you do not want to be.
- You have the right to change your mind and leave the study at any time without giving any reason, and without penalty.
- Any new information that may make you change your mind about being in this study will be given to you.
- You will be given a copy of this consent form to keep.
- You do not waive any of your legal rights by signing this consent form.

<u>Questions about the Study or Your Rights as a Research Participant</u>

- If you have any questions about the study, you may contact the investigator listed below at 404-894-8344.
- If you have any questions about your rights as a research participant, you may contact Ms. Kelly Winn, Georgia Institute of Technology Office of Research Compliance at (404) 385-2175.

If you sign below, it means that you have read (or have had read to you) the information given in this consent form, and you would like to be a volunteer in this study.

____
Participant Name (please print)

____
Participant Signature **Date**

____
Name of Investigator Obtaining Consent (please print)

____
Signature of Investigator Obtaining Consent **Date**

APPROVED *Consent Form Approved by Georgia Tech IRB: April 01, 2009 - March 31, 2010*

D.9 Experimental Protocol

I. Informed consent

II. Administer ability tests
   a. Test for far and near vision
   b. Test for perceptual speed (Digit Symbol Substitution)
   c. Test for memory (Reverse Digit Span)
   d. Test for vocabulary (Shipley Vocabulary Test)

III. Core experimental phases
   a. Phase 1
      i. Provide initial instructions and read aloud
      ii. Provide task analysis topic
      iii. Collect initial task analysis
   b. Phase 2
      i. Provide instructional material 1 (general)
      ii. Provide instructional material 2 (specific to condition)
      iii. Provide task, wait, and then collect task analysis (repeat twice)
   c. Phase 3
      i. Short break
      ii. Provide Demographics and Experience Questionnaire & Contact Information Sheet
   d. Phase 4
      i. Provide task, wait, and then collect task analysis (repeat twice)

IV. Task questionnaire
   a. Provide questionnaire
   b. Be available to answer questions and note any questions/comments
   c. Collect questionnaire

V. Task analysis questionnaire
   a. Provide questionnaire
   b. Be available to answer questions and note any questions/comments
   c. Collect questionnaire

VI. Debriefing
   a. Provide participant with debriefing form and read aloud
   b. Answer questions participant might have
   c. Thank participant for completing experiment

VII. Compensation
   a. Assign credit

D.10 Debriefing

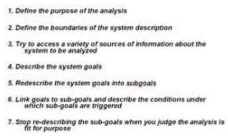
21 Jan 2010

Training Novices on Hierarchical Task Analysis

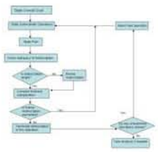
Debriefing Information

Thank you very much for participating in this study. This study was conducted to help us understand what instructional method is most effective when training novices on Hierarchical Task Analysis (HTA). We assigned you to one of three instructional conditions that emphasize different aspects of HTA: procedural instructions, decision action diagram, or concept map. The following are examples of the three conditions:

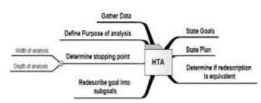
Procedural Steps



Decision-Action Diagram



Concept Map



We are interested to see how the different emphases affect the resulting task analyses. More generally, this study will provide us with information regarding how the training of HTA affects acquisition of skill in the early stages. In addition, it will allow us to gauge the complexity and amount of information learned from the training, through the performance of conducting the analyses. The purpose of the study is also to explore the nature of errors that occur as well as how familiarity with the tasks to be analyzed will affect the resulting analysis.

If you are interested, we will share a summary of the results with you by mailing you a newsletter at your request. Because each individual's data and test scores are completely confidential, there will be no way for us to mail your individual results. Your data will provide valuable insight into training of HTA. If you have any questions, please feel free to contact us. Your experimenter was Anne Adams.

Thank you for your time and cooperation.

Human Factors and Aging Lab

Georgia Institute of Technology (404) 894-8344

Dr. Dan Fisk and Dr. Wendy Rogers

APPENDIX E: STUDY 2 - RESULTS

E.1 Coding Scheme for Task Analysis Products

(1) Hierarchy Dimensions (see Appendix C.1)

(2) Goal

A task analysis will be difficult to read/comprehend without any reference to the high-level goal. Thus, stating the high-level goal at the beginning of the task analysis is important. Code whether the main goal was mentioned as given to the participant (e.g., "Making a peanut butter jelly sandwich"), whether the wording was adjusted (e.g., "Making a sandwich that tastes good"), or not mentioned at all (not mentioned).

(3) Subgoal

Stating subgoals or redescribing super-ordinate goals into sub-ordinate goals is a main feature of HTA. To assess whether participants recognized this main feature task analyses were coded for whether participants stated the word/label "subgoal" somewhere in their task analysis. Secondly, two coders coded the content of participants' task analysis as to whether it was mentioned in the master task analysis created for each task (see Appendix C.1)

(4) Plan

The plan specifies the sequence and the conditions under which subgoals are accomplished. Code participants task analyses on two aspects: (1) did the participant specify (label) the plan as such (the word "plan was mentioned/not mentioned), and (2) what style did the participant use to express the sequence: list (bulleted), list (numbered), list (other), paragraph/text, flowchart, hierarchy, picture, combination, other.

(5) Criteria

It is important in HTA to state criteria or constraints against which task completion is or can be evaluated. Code a task analysis as to whether the participant included criteria, that is, mentions a criterion for satisfaction or checking for satisfaction (mentioned/not mentioned), irrespective of where in the task analysis this is mentioned. For example, “make a cup of tea <u>to taste</u> (milk and sugar)”.

(6) Versatility (see Appendix C.1)

E.2 Reliabilities for Coding in Study 2

Table E.1

Coder Agreement for Task Analysis Products, HTA features, and Decision Factors

Category	Percent Agreement	Cohen's Kappa
Task Analysis Products		
Making sandwich	85%	.81
Making breakfast	74%	.68
Making Vetkoek	83%	.77
Making phone call	80%	.72
Arranging meeting	74%	.68
Sharing pictures	77%	.71
Declarative knowledge	85%	.81
Decision Factors		
Subgoals/Goals *Level* 1	97%	.96
Subgoals/Goals *Level* 2	96%	.95
Breadth *Level* 1	90%	.85
Breadth *Level* 2	69%	.66
Depth *Level 1*	94%	.92
Depth *Level 2*	76%	.73

Note. Coding reliabilities are not adjusted for disagreements in segmentation.

E.3 Adjusted Standardized Residuals

Table E.2

Adjusted Standardized Residuals For Versatility of Task 1

Versatility	Making sandwich	Making phone call
Specific	3.79	1.26
General	- 2.35	- .78

Table E.3

Standardized Residuals For Main Goal Before and After Training

Main Goal	Making sandwich	Making phone call
Before training	- 4.24	- 4.01
After training	- .71	- .47

Table E.4

Adjusted Standardized Residuals of Main Features By Training Condition

Feature	Steps	Decision-Action	Concept Map
Goal	- .35	- 2.09	- .70
Subgoal	- .35	- 1.39	- 1.39
Plan	-1.73	- 1.38	- .35
Criteria	-3.29	- 2.69	- 2.99

Note. Expected counts are based on maximum accuracy.

E.4 Breadth and Depth for Task Analyses Before and After Training

Table E.5

Breadth and Depth of Making Sandwich and Making Phone Call Before and After Training

Task	Breadth			Depth		
	M	*SD*	*Min-Max*	*M*	*SD*	*Min-Max*
Sandwich						
Before training	5.50	2.36	3-11	1.33	.49	1-2
After training	5.94	2.94	2-13	2.17	.79	1-4
Phone						
Before training	4.22	1.70	1-8	1.11	.32	1-2
After training	4.06	2.44	2-10	2.33	1.19	1-5

Note. 18 participants analyzed the task of sandwich (phone) before and 18 participants analyzed the same task after training.

E.5 Plan Label By Training Condition

Table E.6

Number of Task Analyses With the Label "Plan" By Training Condition

Condition	Task 1	Task 2	Task 3	Task 4	Task 5	Task 6	Total	%
Steps	0	4	3	2	3	2	14	19.44
Decision-Action	0	4	2	4	4	4	18	25.00
Concept Map	0	8	7	6	5	7	33	45.83
Total	0	16	12	12	12	13	65	30.09

Note. Maximum total per task is 36 and overall is 216.

E.6 Coding Scheme for Decision Factors

Table E.7

Coding Scheme for Identifying Goals and Subgoals and Deciding on Breadth and Depth of the Task Analysis

Code	Example
1: Definition-based	Answer describes or focuses on the definition of a concept, point, or circumstance
11: Goal / Starting point	- *A goal is..* - *I started when the task started* - *The starting point was..* - *from..*
12: Subgoal / Ending point	- *A subgoal is…* - *I ended when the task was completed* - *to..*
13: other	General definition of breadth
2: Process-based	Answer describes or focuses on an action
21: Using a Person-factor	Reference point is a person
21a Own knowledge	- *based on my knowledge*
21b Another's knowledge	- *thought of my brother* - *assumed common knowledge*
21c other	- *fatigue* - *write for another person to use* - *familiarity* - *how I would do it?*
22: Using a Task-factor	Reference point is the task - *Task complexity* - *Task requires a lot of steps*
23: Other	Reference point is anything other than the person or the task - *Thought of simplest way to do it* - <u>*Thought about*</u> *it from the beginning to the end* - *I tried to be detailed*
3: Other	Didn't do it. No answer

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